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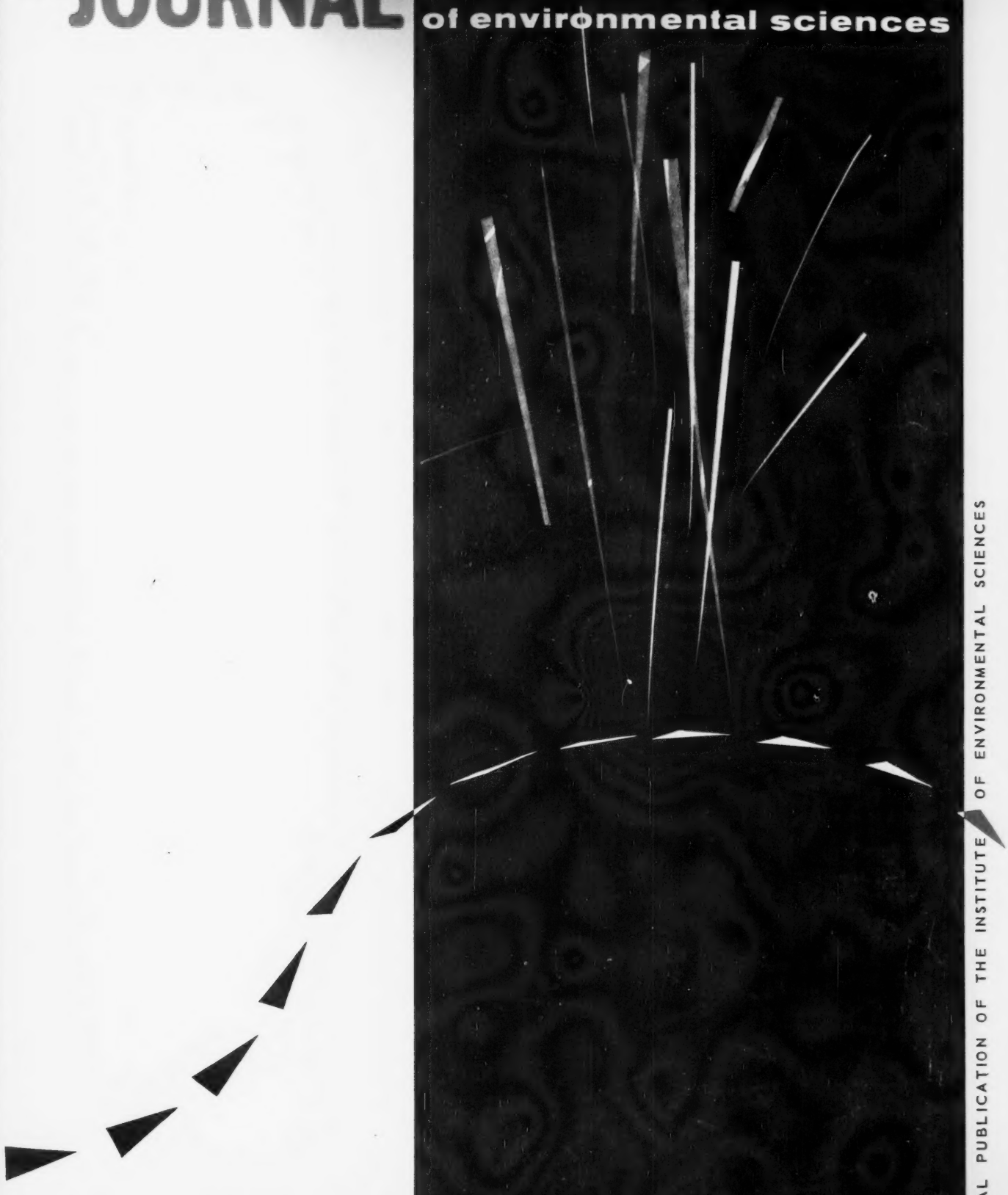

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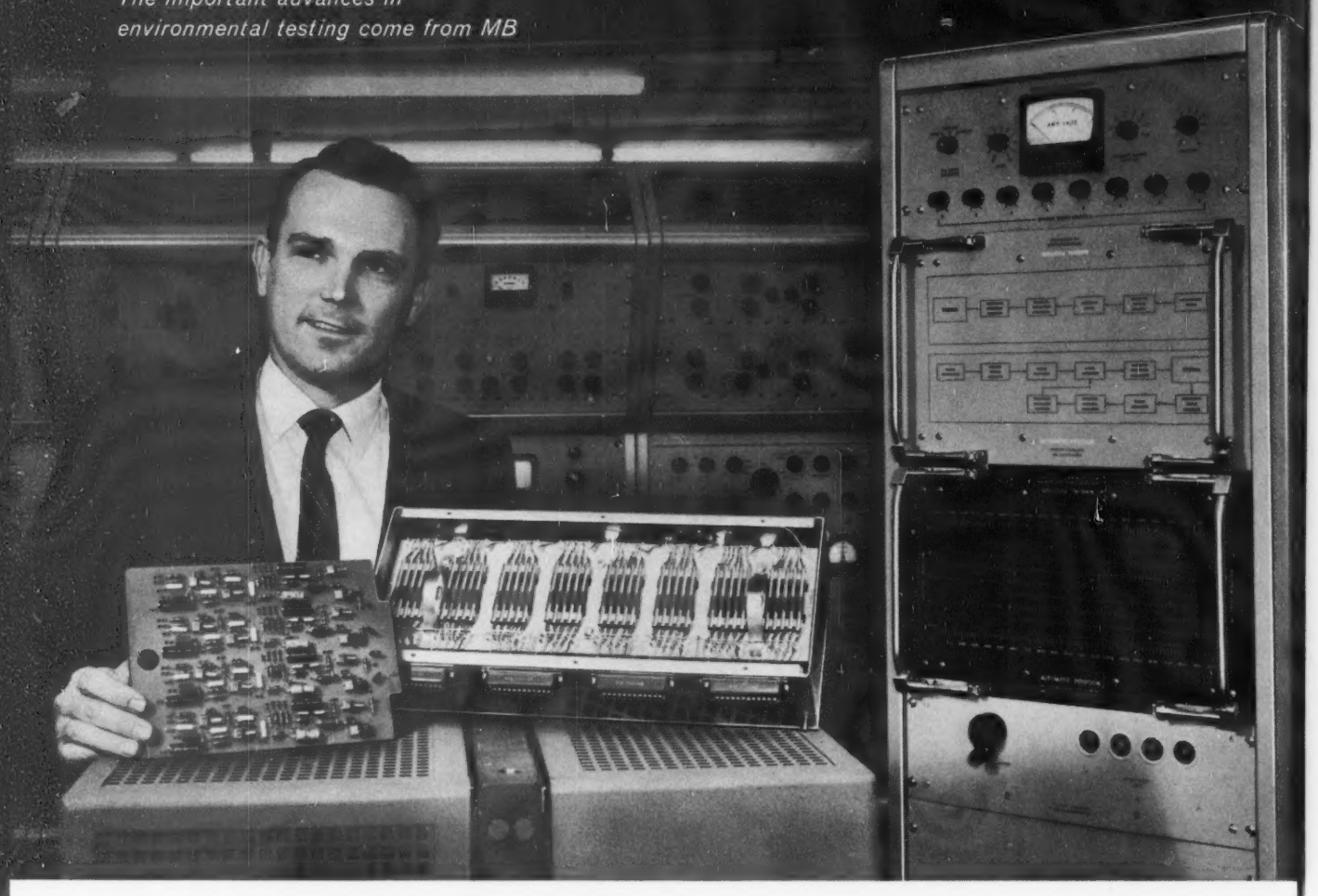
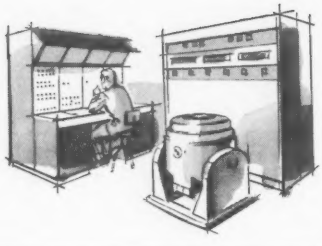
MARCH – APRIL 1961

The important advances in environmental testing come from MB



NEW MB automatic spectrum equalizer to revolutionize random vibration testing



Heart of the MB automatic equalization system is the multi-channel transistorized amplifier which provides amplitude control. The plug-in printed circuit assembly shown above contains four of these channels. Frequency control is provided by the 80-channel filter assembly in the compact metal box.

CONSTITUTING a major breakthrough in applied electronics, MB's new *automatic* spectrum equalizer now means not only more accurate vibration testing . . . but tremendous savings as well in test time and money for missile and aircraft manufacturers.

The reason: set-up time has been completely eliminated. Using solid state magnetostrictive filters with correct phase properties plus servo systems on each of eighty channels in the 15 to 2000 cps spectrum, vibration shaker systems can be completely equalized within 5 seconds.

Savings in time and labor over previous equalization methods can easily mean thousands of dollars per missile tested. Still another advantage is the greatly increased accuracy of accumulated test data. The spectrum is continuously monitored in narrow bandpass channels and compensation automatically made *during* test run.

Automatic spectrum equalization is another of MB's important and continuing contributions in the field of environmental testing.

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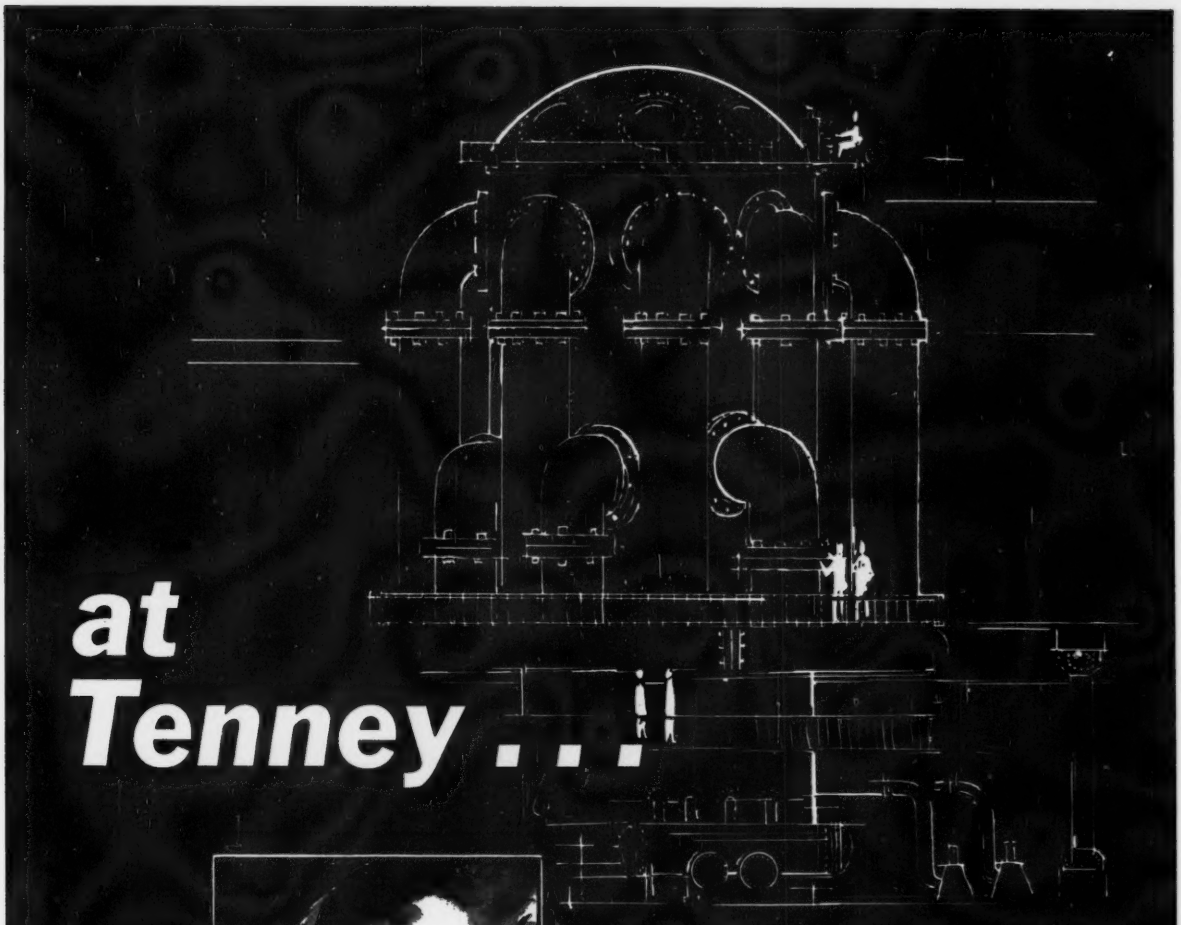

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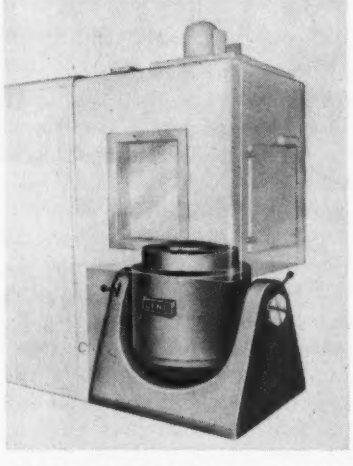

SPECIFICATIONS FOR LING'S MODEL 300 SHAKER INCLUDE:

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1 inch, peak to peak
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VOLUME 4 NUMBER 2

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For active Environmental Engineers and the executives throughout industry who are concerned with the advancement of Environmental Engineering by the Institute of Environmental Sciences.

Charles W. Danielson, Technical Editor

Robert Whiting, Associate Editor

MARCH-APRIL 1961

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TESTING IN A ZERO-G ENVIRONMENT

G.S. REITER and D.A. LEE — *Space Technology Laboratories, Inc.*

ABSTRACT:

The "zero-gravity" or free fall environment is defined and some of its effects on people and on fluids are described. The drop test and airplane techniques for achieving temporary freefall conditions are discussed. The zero-g airplane test facility operated by Wright Air Development Division is described in detail. An STL experiment, conducted in the WADD facility, is described and discussed.

WHAT IS ZERO-GRAVITY?

The so-called "zero-g" environment is actually one in which the pull of gravity is the only external force acting on a body. That is, a condition in which things are falling freely under gravity.

Since in free-fall everything at the same altitude moves with the same acceleration, thrown objects appear to a falling observer to move in a straight line, just as if there were no gravity. This is why the effect is generally called "zero-gravity".

Most natural phenomena behave about the same in zero-g as under normal conditions. An exception is liquid behavior. Under zero-g the surface of a glass of water will bulge out and, if the glass is shaken gently, blobs of water will fly out. The contraction of the water into large drops is not exactly an effect of zero-gravity. It is an effect of the surface tension of the water, which is ordinarily obscured by the stronger effect of gravity.

Humans are affected only slightly by zero-g. The sensation of suddenly entering zero-g is very similar to going "over the top" on a roller-coaster. Once in the environment, zero-g feels much like underwater swimming. There is no sensation of falling, and it is impossible to tell up from down without looking. Walking on the ceiling is just as easy (or rather, just as hard) as walking on the floor.

In general, people tend to overestimate the forces required to move in zero-g. As an example, a gentle push at the wall will impart a fairly high velocity to a floating man, sometimes with comical results.

WHY IS ZERO-G IMPORTANT?

Right now there is a great deal of interest in zero-g. Many zero-g experiments are being carried out in heat transfer, fluid flow, medicine and other fields. People are interested in zero-g because it is part of the environment found in space.

On earth, we live in a nearly uniform gravity field. The pull of gravity is reacted by the earth, resulting in the sensation of weight. When there is no direct reaction to gravity, as, for example, in a satellite, which moves under the influence of gravity alone, everything falls with the same acceleration, so that anything designed to work in a satellite or space vehicle that is neither thrusting nor spinning must be capable of functioning in a free fall environment. Evidently, an important factor in our success in space will be our ability to cope with the affects of zero-g on men and equipment. This is going to require more and more zero-gravity testing.

HOW IS ZERO-G ACHIEVED?

The most obvious way of testing in a zero-g field is to put the experiment in orbit. Dismissing this as overly expensive, it is natural to look around for other ways to produce temporary zero-g conditions.

One method that has been used on occasion is to locate an experimental package inside a nose cone that is fired on a standard ballistic missile test flight. This method is very useful for small experiments that are capable of remote operation, as it provides a period of roughly 30 minutes of zero-g.

The most obvious way to achieve zero-g is to drop the experiment and let it fall. For short time durations this is an excellent test technique, but it is limited by air drag on the falling body and by the drop height required.

For example, even if air drag were not important, a four-second duration would require a 25-story drop. Actually, air drag would build up rapidly on the falling body and would soon nearly balance the attraction of gravity, so that the experiment would no longer be falling freely and would not be in zero-g. Two seconds is about the longest practical duration for this type of testing.

Another important technique for zero-g testing is in using an airplane as a refinement of the drop test. In airplane testing the effect of aerodynamic drag on the falling body is eliminated by flying the airplane around the falling object. Since the airplane can't fly straight down, the body is given a large horizontal velocity so that the plane can fly in a shallow dive as shown in Figure 1.

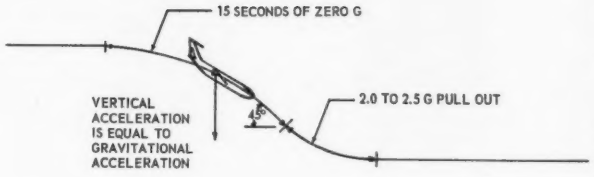


FIGURE 1

The vertical acceleration of the airplane is maintained nearly constant and equal to the local acceleration of gravity, while the horizontal acceleration is maintained at zero.

For increased zero-g time, the airplane can throw the body upward, and then fly around it. To accomplish this the plane pulls up and accelerates on a climb, pushing the experiment with it. Then the plane stops accelerating and flies around the experiment. The flight profile is shown in Figure 2.

Adding the climb portion approximately doubles the zero-g flight time, so the parabolic flight path is always used. With present airplanes, the maximum float times are about 15 seconds for propeller planes, about 30 seconds for jet transports, and about 60 seconds for jet fighters.

The technique of achieving zero-g in an airplane is the most useful of the three and since our experiment was done with that type of testing, the rest of this discussion will be devoted to zero-g testing in an airplane. We performed our experiment with the airplane operated by the Wright Air Development Division, in Dayton, Ohio. The airplane used is a KC-135, which is almost identical to the well-known Boeing 707. WADD has a C-131 aircraft also used for zero-g flying.

The WADD aircraft are specially modified for zero-gravity flying. The airplane fuel systems have been modified to ensure continuous flow during the zero-gravity testing, and the airplane cabins have been heavily padded. The cabin of the KC-135, is 80 feet long, 10 feet wide and 7 feet high.

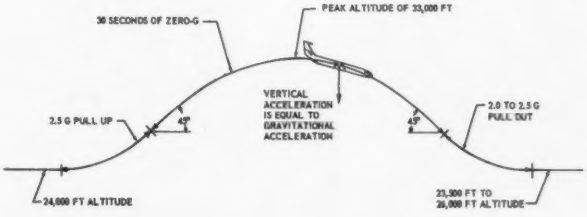

30 SECONDS OF ZERO-G
PEAK ALTITUDE OF 33,000 FT
VERTICAL ACCELERATION IS EQUAL TO GRAVITATIONAL ACCELERATION
2.5 G PULL UP
45°
45°
2.0 TO 2.5 G PULL OUT
24,000 FT ALTITUDE
23,500 FT TO 26,000 FT ALTITUDE

FIGURE 2

The airplane uses a crew of three: pilot, co-pilot, and flight engineer. Three to ten passengers generally are taken along, including photographers, observers, and people conducting the experiment.

A typical flight is planned along the following lines:

The flight preparations begin with a briefing conducted by the pilot. The flight plan, the weather and the experiment procedure are discussed in detail. For the benefit of new personnel, the captain describes the safety requirements, flight clothing requirements, and other important points such as how to get out of the plane in an emergency.

FIGURE 3

After takeoff, the pilot climbs to 25,000 ft and enters a special area assigned to the zero-g mission and into which no other plane is permitted. About 15 minutes after takeoff, the plane is ready for the flight maneuver. The plan is put into a very shallow climb at full military power for about 30 seconds. The pilot then pulls up sharply for about twelve seconds to an angle of about 45°. The upward acceleration of the airplane during the pullup is about 2 1/2 g's, which is the most the airplane wings can safely take. The downward pull on the plane personnel during this period is very uncomfortable. When the plane reaches the 45 degree angle, the pullup stops and the pilot slows the engine to the point where the thrust cancels the drag. At this point the airplane is in free fall and anything in the cabin which is not tied down will fly up and float around.

The experiments conducted during the free fall period usually involve either floating people or some type of floating package. While the experiment is being performed, the pilot must use his instruments to fly the plane around the capsule without touching it. He also can observe the falling or seemingly floating capsule on a closed circuit TV system. Since air turbulence continually moves the plane, this task requires a highly skilled pilot. At the present time, although the aircraft is nominally capable of 30 seconds of free fall, ten seconds without a bump is considered an excellent maneuver.

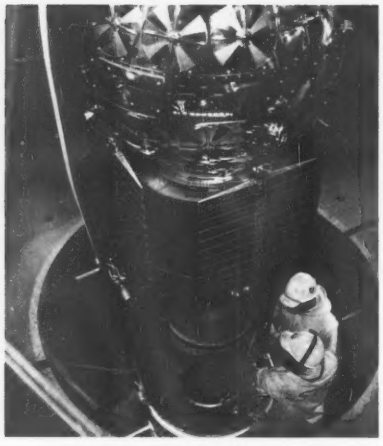


FIGURE 4

The maneuver consists nominally of a parabolic climb from 25,000 ft to 33,000 ft and back again. Near the end of the maneuver, the pilot puts the plane in a slightly positive g condition to settle all floating objects gently to the floor, and then enters another 2 1/2 g pull-up to bring the plane out of the maneuver.

Typical flights in the KC-135 takes about 2 1/2 hours, and it is possible to conduct as many as 30 maneuvers during this period, if the experiment can be readied quickly for each new maneuver.

Except for the unsettling effect of the pull-up and the zero-g condition itself, working conditions in the airplane are very comfortable. The cabin is pressurized, and is kept slightly chilly (55° F) to reduce the effect of airsickness. More than 50% of the people who try zero-g for the first time become severely airsick. However, this rate rapidly declines as people become accustomed to the frequent transitions from 2 1/2 to "zero-g" and back.

Everyone who flies in the KC-135 is required to take Air Force survival and altitude training, which takes about a week. The training includes a physical exam, training in use of parachute and oxygen, survival training for use in the event of a bailout, and a trip to 43,000 ft in an altitude chamber, as well as an optional sudden decompression.

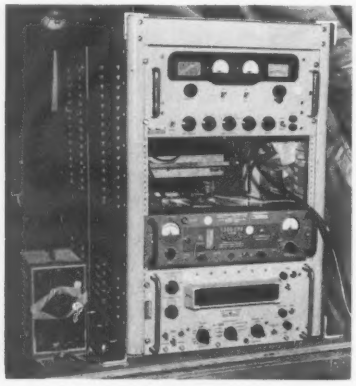


FIGURE 6

FIGURE 5

THE STL EXPERIMENT

The STL experiment, conducted last August, was concerned with the Able-5 Space Vehicle, which was intended to be put in orbit around the moon last December. Because of a first-stage failure the lunar orbit was not achieved. This space vehicle is spin-stabilized and contains a spherical tank of hydrazine fuel. Able-5 is shown in Figure 3, and the upper stages in Figure 4.

Spin-stabilized rockets containing liquid behave just like spinning liquid-filled gyroscopes. Under certain conditions, which are not well understood, such a gyroscope will start to wobble and eventually enter into a violent tumbling motion. To make sure that no tumbling would occur in the Able-5 launch, it was found necessary to determine experimentally the stability of a portion of the vehicle, under zero-gravity conditions.

Since the actual rocket is too large to put in an airplane, an inertially scaled model was built, as shown in Figure 5. The model weighed about 60 lbs. and was about 3 feet high. A turntable was designed, as shown in Figure 5 to spin the capsule prior to its release.

One of the big problems in the experiment was the instrumentation. In ordinary zero-g experiments, a trail-

(Continued on page 18)

FIGURE 7

Vibration, Shock, and Acoustic Noise Associated With Space Vehicles

D.G. Douglas
Space Technology Laboratories, Inc.

ABSTRACT

Causes of space vehicle vibration are categorized into missile engine acoustic noise, aerodynamics, and separation shocks on the basis of vibration data received from Able Star vehicles and sound pressure data taken on Atlas missile flights and ground tests. Data are presented as a time history, that is, excitation versus flight time. Power spectral densities of vibration during critical portions of several flights are compared. Methods are discussed for selecting test specifications for vibration and acoustic environments. Data acquisition techniques, data reduction, and end-to-end calibration procedures are presented.

SUMMARY

Analysis of telemetered vibration data received from Transit-Courier launchings, using Able Star space vehicle equipment, indicates three major sources of Vibration. These are missile engine acoustic noise at liftoff, aerodynamic effects as the missile reaches Mach 1, and separation shock when the second stage vehicle is launched. These measurements were taken at the Able-Star instrument platform, thus very little vibration if any was induced by turbopumps, alternators, or snap-operating valves. Vibration decreases to extremely low levels between the three periods of major excitation; therefore, transmission of vibration directly from the rocket engine through the missile structure has negligible effect on space vehicle equipment.

Data obtained are useful in establishing equipment environmental test criteria. Specifications requiring sinusoidal combined with random vibration are indicated by some functions and shaped random, emphasizing certain frequency regions, are suggested for other functions.

DISCUSSION

While the vehicle is still on the ground, the intense acoustic field created by the rocket engine exhaust is reverberated from the ground back to space vehicle components. This source of excitation diminishes rapidly as the vehicle gains altitude. For a period of time, the excitation decreases to approximately the preignition hum level, indicating an essentially still condition. When the missile velocity approaches the speed of sound, the excitation increases sharply and reaches a maximum level during the transonic period. This source of vibration decays at approximately the same rate as it built up. The vibration level again diminishes to the preignition level and remains very low until separation, at which time shocks are sensed throughout the vehicle when the connecting bolts are exploded and the second stage engine ignited. These shocks constitute the last major excitation detected.

The pattern of excitation described above is typical of a spacecraft mounted on a boost vehicle. This pattern is shown graphically in Figure 1., vibration versus time curves for the forward section of an Able Star second stage mounted on a Thor booster. The three time history curves are superimposed (Figure 1A) to give a better picture of the overall environment. Although the overall levels at liftoff vary considerably more than those at Mach 1, the time history of the vibration is very consistent. Components mounted from the center to the rear of

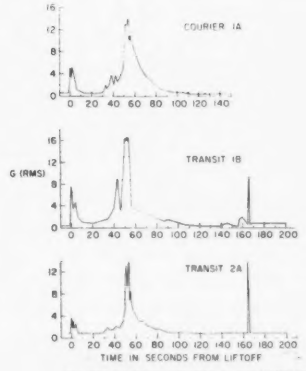


FIG 1 TIME HISTORY OF VIBRATION AT THE INSTRUMENT PLATFORM, ABLE-STAR VEHICLE DURING TRANSIT-COURIER FLIGHTS

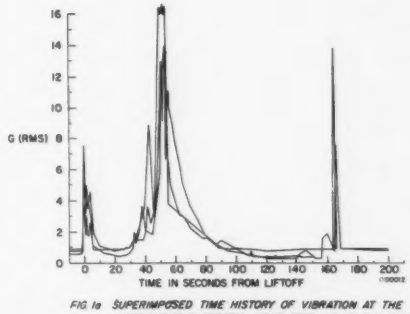


FIG 1a SUPERIMPOSED TIME HISTORY OF VIBRATION AT THE INSTRUMENT PLATFORM, ABLE-STAR VEHICLE DURING TRANSIT-COURIER FLIGHTS

the boost stage sense an additional excitation when the vehicle passes through the region of maximum aerodynamic pressure.

Power spectral density analyses of the maximum sustained vibration dectected at liftoff (Figure 2) show a similarity of spectral distribution, although the overall level varies considerable between flights. (Sustained vibration is defined as peristing for two seconds with no greater than a 3 db root-mean-square change based on a 0.25 second response.)

Power spectral density analyses of the vibration at Mach 1 (Figure 3) show that the overall levels and the spectral distributions are similar. When these analyses are superimposed (Figure 3A) the overall outline or envelope may be described in the following manner: Random vibration from 525 cps to 1100 cps (3 db points of the high pass and low pass filters respectively); high pass filter 12 db per octave, low pass filter 9 db per octave, overall level 31g rms. Although this combination encompasses all data experienced, it would not represent a realistic test specification since the total energy is approximately twice that of the worst case. Also, it eliminates low frequency vibration which could reveal manufacturing defects. This problem is overcome by specifying a sinusoid in conjunction with the random vibration.

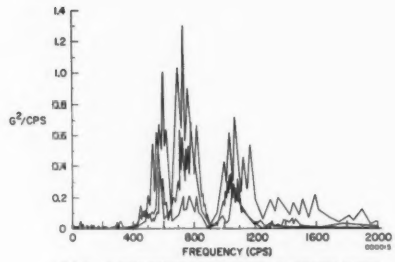


FIG. 3a SUPERIMPOSED POWER SPECTRAL DENSITY DURING TRANSONIC PERIOD AT THE INSTRUMENT PLATFORM, ABLE-STAR VEHICLE DURING TRANSIT-COURIER FLIGHTS

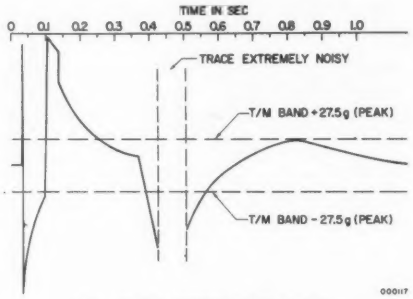


FIG.4 TYPICAL STAGING SHOCK PATTERN

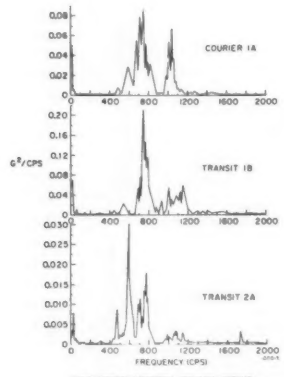


FIG.2 POWER SPECTRAL DENSITY VERSUS FREQUENCY AT LIFTOFF OF THE INSTRUMENT PLATFORM, ABLE STAR VEHICLE DURING TRANSIT COURIER FLIGHTS

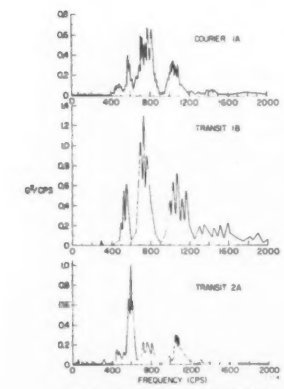


FIG.3 POWER SPECTRAL DENSITY DURING TRANSONIC PERIOD AT THE INSTRUMENT PLATFORM ABLE-STAR VEHICLE DURING TRANSIT-COURIER FLIGHTS

In this case, $0.1g^2$/cps is suggested combined with a 3.5g rms sinusoidal sweep covering the frequency range from 5 to 2,000 cps (limited to 0.4 inches double displacement).

Figure 4 shows the general shape of a typical separation shock. Because these shocks completely overdrove the telemetry system, it is felt that the transit decay affect was caused by the electronic system and does not represent the environment produced by the shock. The main purpose of presenting this figure is to discourage the misinterpretation of shock data transmitted by an instrumentation system set up to measure vibration. The only information that can be acquired from such a pulse is that a shock was experienced at a particular time. If more knowledge of separation shocks is required, it is suggested that ground tests be conducted using a system designed to measure shock.

Acoustic measurements describing excitation at liftoff and Mach 1 are planned for Transit 3A. Unfortunately, these data will not be available in time for this report. Because of the importance of this source of excitation, data of Atlas sound pressure levels are included. Typical power spectral density analyses of the acoustic levels inside and outside the Atlas pod area are shown in Figures 5, 6, and 7. The units plotted here are

$(dynes/cm^2)^2/cps$. These units are analogous to $g^2 cps$ and have the same advantages in that interpretation of the curves is not dependent on the bandwidth of the spectrum analyzer. If a specification representing acoustic data were required, the interior pod environment could be approximated by shaping the acoustic spectrum with a 10 db per octave low pass filter set at 425 cps. This simulated environment would have an overall level of 146.5 db. In this case, the shaped environment would be a realistic specification. The external data approximates the characteristic curve of a 5.7 db/octave low pass filter set at 375 cps with a total level of 152 db.

INSTRUMENTATION AND DATA PROCESSING

Vibration and acoustic data were acquired using piezoelectric transducers. Advantages of this type transducer are high frequency response, broad sensitivity range, and light weight. System calibrations were checked with an end-to-end calibration procedure consisting of applying a known stimulus to the environmental transducer and recording the signal at the telemetry output. In the case of vibration, the flight accelerometer was removed from its mounting position and attached to a small vibration machine adjacent to a reference accelerometer. Acoustic end-to-end calibrations were achieved by placing the flight microphone inside a pre-calibrated acoustic chamber ("squawk box").

Data processing consisted of first obtaining a high frequency response reproduction of the data; a Miller Cathode Ray Oscillograph was used for this purpose.

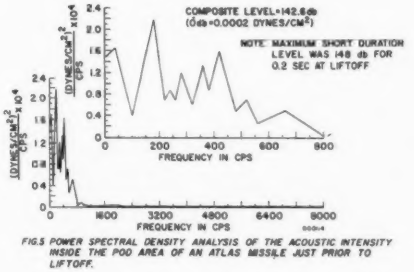


FIG.5 POWER SPECTRAL DENSITY ANALYSIS OF THE ACOUSTIC INTENSITY INSIDE THE POD AREA OF AN ATLAS MISSILE JUST PRIOR TO LIFTOFF.

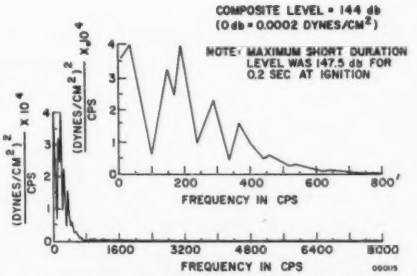


FIG.6 POWER SPECTRAL DENSITY ANALYSIS OF THE ACOUSTIC INTENSITY INSIDE THE POD AREA OF AN ATLAS MISSILE DURING A STATIC FIRING

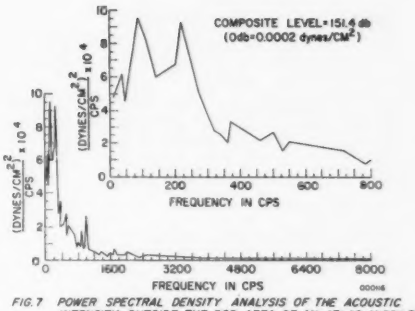


FIG.7 POWER SPECTRAL DENSITY ANALYSIS OF THE ACOUSTIC INTENSITY OUTSIDE THE POD AREA OF AN ATLAS MISSILE DURING A STATIC FIRING

This oscillogram enables one to read peak acceleration values and locate areas of questionable data. RMS analyses were then performed by passing the data through a Ballantine True RMS voltmeter. Readings were plotted using the mean square output of the Ballantine meter. A comparison of the peak and RMS analyses gives a good indication of the amplitude distribution. If the amplitude is normally distributed, the peak will be approximately 3 times the RMS, assuming the high frequency response playback represents 99.74% of the data (3 σ).

Power spectral density analyses were performed using a Davies wave analyzer. The bandwidth was nominally 6 cps, integrating time 2 seconds, sweep rate 0.3 cps per second, and data loop length 2 seconds. For acoustic data the tape speed was decreased to ¼ normal speed, increasing the frequency range of the Davies from 2,000 to 8,000 cps. The bandwidth and sweep rate were not manually changed, thus the bandwidth became equivalent to 24 cps and the sweep rate equivalent to 1.2 cps/second. The integrating time was increased to 8 seconds to correspond with the physical time of the 2 second data sample.

CONCLUSIONS

From the data presented, it appears that mechanical vibration transmitted along the missile from the engine to a space vehicle is negligible. Shock data recorded with a vibration monitoring system has little value. Because of telemetry limitations, shock data should be acquired through ground test measurements. Studies of sound pressure levels during an entire flight are necessary to differentiate between acoustic and aerodynamic influences, particularly at Mach I and during the period of maximum aerodynamic pressure. Vibration measurements should be taken simultaneously as a reference. The data resulting from these procedures will be of considerable value in establishing improved designs and specifications required for future space vehicle equipment.

*Environmental Engineering for Operational Reliability of Ground Electronic Equipment Systems

† *Col. B.M. Chakravarti and* † *P.S.K. Prasad*

EDITOR'S NOTE

The following article was taken from "ELECTRO TECHNOLOGY," The Journal of the Society of Electronic Engineers of Electronics Research & Development Establishment, Bangalore, India. The article is presented in its entirety with no cutting or editing.

ABSTRACT

Every system has an element of unreliability inherent in it. In military equipment systems, however, unreliability cannot be tolerated. The designer of military equipment systems therefore, should attempt to reduce the element of unreliability, as far as it is practicable to do so, in consonance with the "state of the art".

There are many factors that could affect the reliability of a system, the most important of them being the environment in which the equipment functions. It is the aim of this paper to lead to a realisation of how operational environment could lead to malfunctioning of military electronic equipment systems and what measures are necessary to combat this, at the design stage.

The paper attempts to show that, in this "Electronic Era," the designing of a complicated military electronic system is an integrated work between many disciplines of science and technology. The design of a reliable electronic equipment can be undertaken only by a team consisting of Electronic Engineers, Physicists, Chemists/Chemical Engineers and others. Reliability can be achieved only if it is set as a parameter of design and never as an afterthought.

The paper enumerates the various environmental hazards such as high and low temperatures, low-pressure, high velocity winds, snow, high relative-humidity, biological growth, driving rain, immersion, saltspray, sunshine, dust and sand, shock and vibration, bringing out the nature and extent of deterioration each environment causes and how the environmental engineer could build adequate protection into the equipment, against each of them. The paper clearly emphasizes the fact that environmental requirements provide the key parameters in the overall design and selection of a circuit design.

The paper concludes, that the environmental engineer has a very important role to play in ensuring overall reliability in the design of military electronic equipment. The paper further points out that the problems of repair and maintenance could be solved to an appreciable degree by ensuring the incorporation of environment as a parameter for design of military electronic equipment.

INTRODUCTION

A modern military equipment has to be failure-proof, or reliable under all operational conditions. In any complicated system there is a certain inherent element of unreliability which probably is very difficult to remove entirely. What is however attempted is to reduce the element of unreliability. The greatest cause of unreliability in military electronic equipment, particularly in India, is the lack of maturity of product design and the inability to evaluate the inherent unreliability of design through realistic engineering evaluation processes.

RELIABILITY

Reliability could be defined as "the *probability* of a *device performing* its purpose *adequately* for the *period of time* intended under the *operating* conditions encountered.[28]" It can be achieved only if it is set as a goal at the beginning of the design procedure. There are many factors that could affect reliability, one major factor being the environment in which the equipment functions. Electronic circuitry design techniques have advanced to the point where these can be made to do the most exacting jobs. But circuits are of little value unless they can deliver the goods under operational environments. In order to ensure this, environmental factors must be considered as design parameters.

INTEGRATED GROUP WORK

Hitherto, the design of electronic equipment has primarily been the concern of the electronic engineer only. Many of them, although well skilled in their own profession, are frequently unfamiliar with the talents and skills in other allied engineering fields. The phenomenal advance of Electronics in recent times, has made it impossible for *Reliability* to be treated as a vague after-thought. Therefore, the design and development of military electronic equipment has to be a combined effort of electronic engineers, physicists, chemists, chemical engineers, mechanical engineers and many others.

OBJECT

The object of this article is to show that in military electronic equipment the operational environmental factors form an important design parameter.

* Presented at the First Defense Electronics Convention 1959, Bangalore.

† Electronics Research & Development Establishment, Bangalore.

ELEMENTS OF OPERATIONAL ENVIRONMENT

A soldier is expected to fight under all climatic conditions and in all terrains. The equipment he uses, naturally therefore, must withstand all hazards that he himself is likely to face in combat conditions. In addition, the equipment must also withstand the hazards of combat transportation storage conditions and much rough handling.

ENVIRONMENTAL CONDITIONS

Any military equipment has to undergo the following types of environmental conditions:

(a) Environment in transport.
(b) Environment in storage.
(c) Environment in usage.
(d) A combination of some or all of the above.
(e) Radiation environment—although a very important one—it is not being considered in this paper.

ENVIRONMENT IN TRANSPORT AND STORAGE

Mechanical hazards are encountered during transport and climatic hazards during storage. During usage, however, both are equally predominant.

Special packaging is developed to protect equipment against transport and storage hazards. During use, however, the equipment has no longer the protection of the package. An equipment can withstand satisfactorily the rigours of field usage only if it is designed and processed for it.

ENVIRONMENT IN USAGE

Some important environmental factors encountered during use of an equipment are: temperature (high and low), moisture/water ingress, biological growth, corrosive factors such as salt atmosphere, industrial atmosphere etc., sunshine, sand and dust exposure, shock and vibration. In operational areas the equipment is liable to be exposed to the extremes of the above mentioned factors and often, it is not a single factor, but a combination of them that causes failures of these equipments. Not only individual materials/components deteriorate as a result of these hazards, but in the process of their deterioration, they may influence the deterioration of other materials/components in the assembly and possibly hasten electrical and mechanical failure of the equipment as a whole.

HIGH TEMPERATURE

The highest temperatures of about 49°C (120°F) are recorded in the Rajasthan desert and some in the North-Western part of the country in summer time[2]. During storage it becomes slightly higher—say about 55°C (130°F).[2] Table I shows the high temperatures obtained at different places in India. In addition, there will be a rise of temperature, in closed spaces, due to solar radiation, of about 22°C to 33°C (40°F–60°F).[2]

Besides high ambient temperatures encountered, heat is also generated by some electronic components during operation. For instance, at an ambient temperature of 85°C (185°F) for an equipment in operation, the ambient temperature inside the equipment near some of the components may be as high as 200°C (392°F)[3]. This leads to greater complexities specially for miniaturized hermetically sealed or encapsulated designs where the heat emitting surface for components is less and sealed enclosures do not permit heat dissipation by convection currents of air.

EFFECTS OF HIGH TEMPERATURES

At high temperatures:

(a) Waxes, greases and protective compounds may begin to flow.
(b) The heat distortion temperature of most thermoplastics is below 95°C (203°F). Deterioration of cellulose insulation begins at about 100°C (212°F) with an increase in power factor and decrease in dielectric strength.[3]
(c) Long range ageing processes are accelerated. Organic materials decompose more rapidly and rubber materials harden and set.[3]
(d) Differential expansion of separate elements results in the distortion of assemblies, the rupture of seals and the sticking of movable parts.[3] Laminates may warp.
(e) Constants of resistance, inductance, capacitance, power factor, dielectric constant and strength will vary. Contacts may open or close by warping under expansion.[6]
(f) All components are temperature sensitive as regards their accuracy, stability or life expectancy.[2] A cracked-carbon resistor (grade 1) has temperature coefficient in the order of 0.04% per degree centigrade. This means that a resistor selected to a tolerance of 1% at room temperature (say 20°C) is forced out of tolerance by an increase in ambient of a mere 25°C. The departure from nominal would be about 5.2%, if the ambient is raised to 150°C, without any dissipation at all in the resistor.[2] In the case of a paper capacitor, the insulation resistance is halved for each 10°C raise in temperature.[9] To guard against the catastrophic failure of insulation, it is necessary to reduce the voltage rating to some 60% of that at 70°C. If the voltage within the equipment cannot be reduced then either a large capacitor has to be used at the expense of size or the ambient reduced to a tolerable level[9]. Semiconducting devices also are highly temperature sensitive. Selenium rectifiers are rated at 55 C normally, operation above which, reduces their efficiency as well as working life.

There are thus different temperature levels which are rather critical for various components and it is this disparity among the safe working temperatures of various components that poses the most acute problem for the equipment designer.[9]

The most pressing problem in the design of the electronic equipment is therefore to take preventive action against higher working temperatures that can develop in an equipment. This can be achieved by:

TABLE I

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean daily maximum temperature in °F													
Calcutta	79.6	88.7	92.5	96.6	95.6	92.4	89.5	89.0	89.9	89.2	84.2	79.4	88.5
Kanpur	71.9	77.0	89.4	99.4	106.2	102.7	92.4	89.7	90.9	91.2	82.8	74.0	89.0
New Delhi	70.5	74.7	85.0	96.6	104.8	102.4	95.3	93.0	93.5	92.5	83.2	73.7	88.8
Srinagar	41.0	44.1	56.9	66.8	77.0	85.4	87.8	86.6	85.5	73.8	62.5	48.2	67.8
Ahmedabad	84.8	87.9	97.0	105.8	106.8	101.8	93.1	88.9	92.6	97.2	92.6	86.4	94.5
Bombay	85.2	83.1	86.2	89.1	91.1	88.5	85.5	85.0	85.5	88.8	89.4	86.6	86.8
Coimbatore	86.0	90.9	95.4	96.5	94.4	88.8	86.7	87.4	88.7	87.7	85.4	84.3	89.3
Madras	85.3	88.3	92.4	95.5	101.3	99.6	96.3	94.8	93.9	90.1	85.4	84.1	92.2
Shillong	60.1	62.5	70.4	74.1	74.0	74.5	75.3	75.1	74.3	71.1	66.0	61.6	69.9
Simla	47.5	48.8	57.0	65.9	75.2	75.1	70.9	68.4	68.4	64.3	58.3	50.6	62.4
Mean daily minimum temperature in °F													
Calcutta	54.6	59.4	68.8	75.5	77.5	78.6	78.6	78.3	78.0	73.8	63.7	55.0	70.2
Kanpur	45.7	51.0	60.1	70.6	80.4	63.0	79.9	78.7	76.2	66.0	53.9	46.5	66.0
New Delhi	45.3	49.2	57.1	67.7	78.8	82.5	80.1	78.4	75.5	64.3	51.8	45.0	64.5
Srinagar	27.8	29.3	37.0	44.6	50.9	57.3	64.3	63.4	53.5	40.6	30.9	27.6	43.9
Ahmedabad	57.6	60.0	67.5	74.5	79.2	81.0	78.5	76.8	76.0	72.7	65.6	59.6	70.7
Bombay	68.7	67.4	71.9	76.1	79.6	78.6	76.7	76.1	75.7	75.6	72.5	68.8	73.8
Coimbatore	64.9	66.5	70.2	73.6	73.6	71.9	71.0	71.0	70.9	70.7	69.0	66.0	68.9
Madras	67.1	68.4	72.4	78.1	81.7	81.1	79.3	78.0	77.2	75.0	71.9	68.9	74.9
Shillong	38.8	42.4	50.8	57.0	59.1	65.0	64.6	64.0	61.6	54.8	46.2	40.0	55.5
Simla	35.4	36.1	43.6	50.6	57.7	60.1	59.2	59.2	56.3	51.4	44.2	39.3	49.4
Highest maximum temperature ever recorded in °F													
Calcutta	89	98	104	107	108	104	98	96	97	96	92	87	108
Kanpur	88	96	108	114	117	117	113	105	104	105	97	88	117
New Delhi	84	92	106	111	114	115	113	104	105	101	92	84	115
Ahmedabad	97	105	111	115	118	117	108	102	105	100	102	96	118
Bombay	94	97	101	100	96	99	96	90	95	97	96	94	101
Coimbatore	95	98	102	104	103	101	98	96	96	87	84	85	104
Madras	91	98	102	100	113	110	106	104	102	102	94	91	113
Lowest minimum temperature ever recorded in °F													
Calcutta	44	46	50	61	65	70	73	74	72	63	51	45	44
Kanpur	36	33	45	52	64	69	72	71	61	52	43	35	33
New Delhi	31	35	45	63	65	66	71	72	64	49	39	34	31
Srinagar	6	−4	22	32	37	43	51	50	40	29	18	11	−4
Ahmedabad	39	36	49	57	67	67	70	71	71	61	53	44	36
Bombay	53	53	62	68	73	70	72	72	71	70	64	55	53
Coimbatore	53	55	60	64	65	65	62	63	65	59	57	54	53
Madras	57	59	62	68	70	69	71	69	69	62	59	57	57
Shillong	27	30	31	45	43	53	59	58	53	42	34	29	27
Simla	18	17	22	30	40	46	50	51	41	37	30	21	17

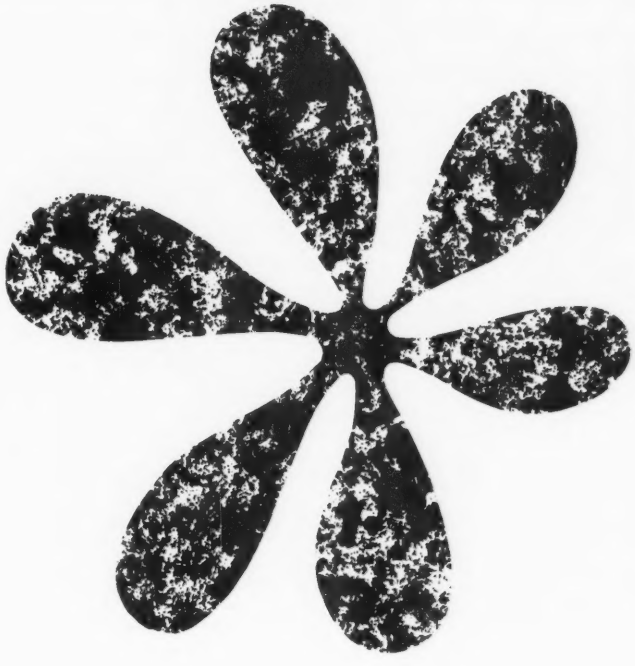
Maximum temperature recorded

i) Sriganganagar 122°F on 14 June 1934
ii) Doosa 122°F on 15 May 1912

Lowest temperature recorded

Dras (Kashmir) −49°F on 28 December 1910

Information furnished by the Indian Standards Institution.



1961

BUYERS' GUIDE

Instructions for using Environmental Buyers Guide

1. Locate type of equipment desired an code sheet and find code number.
2. Go to Guide. Find the major code heading required and follow down column locating code numbers.
3. Follow across code to manufacturers name.
4. Locate manufacturers address on alphabetically listed address sheet.

MANUFACTURER	CODE												
	A	B	C	D	E	G	H	J	K	L	M	N	O
ACALL INDUSTRIAL						5							
ACTON LABORATORIES							1						
AEROTEST LABORATORIES							1						
ASSOCIATED TESTING LABS.							1						
AUTO CONTROL	1,2,3,8,10												
AVCO		5											
BARRY CONTROLS		6	1,3,5										
BEACH-RUSS												1	
BEMCO	1,2,3,4,6,												
	7,9,10												
	11,12												
BETHLEHEM	1,2,3,4,6,		1										
	7,9,10,												
	11,12												
B & K						6							
BLUE M	1,3												
CARDOX											1		
CHADWICK HELMUTH						2							
CINCINNATI					1,2								
COMPUDYNE		4											
CONRAD	1,2,3,4,												
	6,7,8,9,												
	10,11,12												
CONSOLIDATED			4										
CRYOGENERATORS										1			
DELTA	1												
ELECTRICAL							1						
ENDEVCO						1							
GENERAL						1							
GENISCO		1		1									
GUARDITE	1,2,3,4,												
	6,7,12												
GULTON						1							1
HARRIS	1												
HUDSON BAY	1												
IMPACT						1							
INDUSTRIAL	1,2,3,6,7,												
	10,11,12												
INTERNATIONAL RADIANT	1												
I T & T		1	1										
ITEMCO	1,2,3												
ITEMLAB							1						
L.A.B.		3											
LAMBERT								1					
LING		1,2,5											
M.B.		1,2,5											
MICRO GEE				1									
MINNEAPOLIS					1,2,3,5	4							

Acall Industrial Co., Ltd. Atarashi Bldg 7, 2-chome Sarugaku-cho Chiyoda-ka, Tokyo, Japan

Acton Laboratories, Inc., 533 Main Street, Acton, Mass.

Aerotest Laboratories, Inc., Comac Road, Deer Park, L.I., N.Y.

* **Allied Research Associates**, 43 Leon St., Boston 15, Mass.

* **American Instrument Co., Inc.**, 8030 Georgia ve. Silver Spring, Md.

* **American Research Corp.**, Rt. 6, Farmington, Conn.

* **Associated Testing Laboratories, Inc.**, 136 Clinton Road, Caldwell, N.J.

Auto Control Laboratories, Inc., Inglewood, California

* **Avco Corp.**, Industrial Products Subdivision, Research and Advanced Development Division, Wilmington, Mass.

* **Barry Controls, Inc.**, 700 Pleasant Street, Watertown 72, Mass.

Beach–Russ Co., 420 Lexington Ave., New York 17, N.Y.

* **Bemco Inc.**, 11631 Vanowen St., North Hollywood, Calif.

* **Bethlehem Foundry and Machine Co.**, Environmental Engineering Division, 225 W. Second St., Bethlehem, Penna.

* **B & K Instruments, Inc.**, 3026 W. 106th St., Cleveland 11, Ohio

* **Blue M. Electric Co.**, Blue Island, Illinois

* **Cardox**, Division of Chemtron, 840 N. Michigan Ave. Chicago, Ill.

* **Chadwick Helmuth Co.**, 428 East Duarte Rd., Monrovia, Calif.

MAJOR EQUIPMENT

CHAMBERS	**–A**
TEMPERATURE	–A1
ALTITUDE	–A2
HUMIDITY	–A3
SALT SPRAY	–A4
OZONE	–A5
SUNSHINE	–A6
SAND & DUST	–A7
HYDRAULIC	–A8
EXPLOSION	–A9
EXPLOSION PROOF	–A10
RAIN	–A11
FUNGUS	–A12

MACHINES

VIBRATION	**–B**
EXCITERS	–B1
AMPLIFIERS	–B2
MECHANICAL	–B3
HYDRAULIC	–B4
ACOUSTIC	–B5
ISOLATORS	–B6
SHOCK	**–C**
MACHINES	–C1
FIXTURES	–C2
DROP	–C3
HYDRAULIC	–C4
PNEUMATIC	–C5
CENTRIFUGES	**–D**

INSTRUMENTATION

CHAMBERS	**–E**
TEMPERATURE	–E1
HUMIDITY	–E2
ALTITUDE	–E3
OZONE	–E4
SUNSHINE	–E5
VIBRATION	**–G**
ACCELEROMETERS	–G1
STROBE EQUIPMENT	–G2
FREQUENCY COUNTERS	–G3
RECORDERS	–G4
BALANCING	–G5
ACOUSTIC	–G6
DISPLACEMENT	–G7

COMMERCIAL TESTING LABORATORIES

EASTERN	–H
MID-WESTERN	–J
WESTERN	–K

MISCELANEOUS

REFRIGERATION, MECHANICAL	–L
REFRIGERATION, GASEOS	–M
VACUUM PUMPS	–N
ELECTRONIC INSTRUMENTATION	–O

MANUFACTURER	CODE												
	A	B	C	D	E	G	H	J	K	L	M	N	O
MISSIMERS	1,2,3,6,7, 10,11,12												
MURPHY MILLER	1,2,3,6,7, 10,11,12												
NATIONAL RESEARCH							1						
OPTRON						7							
OZONE	5												
PARAMETERS							1						
PURE CARBONIC											1		
RESEARCH					1								
RESCON					1								
ROTOTEST		5							1				
STANDARD	1,2,3,4, 6,7,9, 11,12												
STATHAM	1												
STELLARDYNE									1				
STOKES												1	
TENNEY	1,2,3,4,6, 7,9,11,12												
THE RUCKER				1									
THE STRONG	6												
UNHOLTZ		1,2											
UNITED AERO						1							
UNITED STATES							1						
VARIAN												1	
VIDEO						1							
W.C. DILLON						7							
WYLIE									1				

* **Cincinnati Sub Zero Products**, 3930 Reading Road, Cincinnati 29, Ohio
CompuDyne Corp., 400 S. Warminster Rd., Hatboro, Penna.
* **Columbia Research Lab., Inc.**, MacDade Blvd. & Bullens La., Woodlyr Pa.
* **Conrad, Inc.**, Holland, Mich.
* **Consolidated Vacuum Corp.**, Rochester 3, N.Y.
Cryogenerators Inc., Mendon and Angell Roads, Ashton, Rhode Island
Delta Design Engineers Inc., 7460 Girard Ave., La Jolla, Calif.
* **Electric Hotpack**, Cottman Ave. & Melrose St., Phila., 35, Pa.
Electrical Testing Laboratories, Inc., 2 East End Ave. New York 21, N.Y.
* **Endevco Corp.**, 161 E. California Blvd., Pasadena, Calif.
General Testing Laboratories, Inc., 46 Commercial Ave., Moonachie, N.J.
Genisco Inc., 2232 Federal Ave., Los Angeles 64 Calif.
* **Gruenberg Electric Co., Inc.**, 9 Commercial Ave., Garden City, NY
* **Guardite**, Division of American-Marietta Co. Wheeling, Illinois
* **Gulton Industries, Inc.**, Metuchen, N.J.
Harris Manufacturing Co. Inc., 312 River St., Cambridge 39, Mass.
* **High Vacuum Products**
Hudson Bay Co., Labline Division Inc., 3070-82 W. Grand Ave., Chicago 22, Ill.
Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland 15, Ohio
Industrial Refrigeration Co., Inc., 8940 Ellis Ave. Los Angeles 34, Calif.
International Radiant Corp., 577 E. 156th St., New York 55, N.Y.
* **International Telephone and Telegraph Corp.**, Industrial Products Division, 15191 Bledsoe St., San Fernando, Calif.
Itemco, Inc., 18 Beechwood Ave., Port Washington, L.I., N.Y.
Itemlab Inc., Port Washington, L.I., N.Y.
* **Kistler Instrument**, 15 Webster St. No. Tonawanda, NY
L.A.B. Corp., Skaneateles 7, N.Y.
Lambert Engineering Co., Research and Testing Laboratory 1100 Macklind Ave., St. Louis 10, Mo.
* **Ling Electronics**, 1515 S. Manchester, Anahiem, Calif.
* **Liquid Carbonic Div.**, 135 S. La Salle St., Chicago 3, Ill.
* **M.B. Electronics**, A Division of Textron Electronics Inc., 1082 State Street, New Haven 11, Conn.
Micro Gee Products Inc., 6319 West Slauson Ave., P.O. Box 1005, Culver City, Calif.
* **Minneapolis Honneywell Reg.**, Wayne and Windrim Ave., Philadelphia 44, Penna.
* **Missimers Inc.**, 3737 San Fernando Road, Glendale, Calif.
Murphy and Miller Inc., 620 West Taylor St., Chicago 7, Ill.
* **National Research Corp.**, 70 Memorial Drive, Cambridge 42, Mass.
* **Optron Corp.**, 335 South Salinas St., Santa Barbara, Calif.
Ozone Research and Equipment Corp., 3840 N. 40th Ave., Pheonix, Ariz.
Parameters Inc., 195 Herricks Rd., New Hyde Park, NY
* **Pure Carbonic Co.**, 150 East 42nd St., New York 17, N.Y.
* **Research Inc.**, Box 6164, Minneapolis 24, Minn.
Rescon Electronics Corp., 151 Bear Hill Rd., Waltham 54, Mass.
* **Rototest Laboratories, Inc.**, 2803 Los Flores Blvd., Lynwood, Calif.
Standard Cabinet Co., Inc., 49 Washington Ave., Carlstadt, N.J.
Statham Development Corp., 1845 Pontius Ave., Los Angeles 25, Calif.
Stellardyne Laboratories Inc., 1525 Cuyamaca St. El Cajon, Calif.
* **Stokes Corp.**, 5500 Tabor Rd., Philadelphia 20, Penna.
* **Tenney Engineering Inc.**, 1090 Springfield Rd., Union, N.J.
* **Test Engineering**, 330 Park Avenue, Oakhurst, N.J.
The Rucker Co., 4700 San Pablo Ave., Oakland 8, Calif.
* **The Strong Electric Corp.**, 87 City Park Ave. Toledo 1, Ohio
* **Unholtz-Dickie Corp**, 2994 Whitney Ave., Hamden, Conn.
United Aerotronics Corp., Burlington, N.J.
* **United Testing Lab.**, 573 Monterey Pass Rd., Monterey Park, Calif.
* **United States Testing Co., Inc.**, 1415 Park Ave., Hoboken, N.J.
Varian Associates Inc., 611 Hanson Way, Palo Alto, Calif.
Vibra Sonics Inc., 10 High St., Boston 10, Mass.
Video Instruments Co., Inc., 3002 Pennsylvania Ave. Santa Monica, Calif.
W.C. Dillon and Co., 14598 Keswick St., Van Nuys 7, Calif.
* **Wyle Laboratories**, El Segundo, Calif.

Note: Companies signified by an asterisk (*) are exhibitors in the April 1961 National meeting.

(a) Developing and using high temperature components and materials.

(b) Improving internal heat transfer designs, including incorporation of refrigeration/insulation devices.

IMPROVED COMPONENTS/MATERIALS

Electronic components are normally rated at 85°C.[7] Attempts are being made to increase this in the first instance to 200°C and then reach 500°C and 800°C in two giant steps.[7] In fact there has already been considerable progress in high temperature electron tubes. A number of types will work normally at 300°C.[7] The The General Electric Company, U.S.A. are developing a line of heaterless tubes for 700°C – 800°C,[7] working ambient. Sylvania is marketing reliable and rugged subminiature tubes with 200°C ceiling.[7] Further development work on these lines is going on and the list is growing continuously.[11] Nevertheless, the effort cannot be adequate to keep in step with the ever increasing demands for higher temperature components, at least for sometime to come, as the solution for it depends primarily upon the development of a large number of new materials.[11]

HEAT REMOVAL

Heat removal is probably the foremost problem facing the designer of military electronic equipment. The problem has been high-lighted for two reasons: the relation between reliability and internal temperature of assemblies and the added problems in heat transfer imposed by miniaturization, encapsulation and hermetic sealing, which cannot be treated as simple exercises in mechanical ingenuity but are processes that are fraught with thermal hazards. Military designers normally prefer to ask for ever higher temperature components and materials, thus hoping to get over the difficulty. But they also realise the limitation for this solution, particularly in India, where the components industry is still in its infancy.

The problem of heat dissipation is solved presently by firstly transferring heat from internal heat dissipating components to the external shell of the primary equipment and then transferring heat from the equipment shell to an ultimate heat sink (earth or its atmosphere).

INTERNAL HEAT TRANSFER

(a) Heat conduction may be aided by the following means:

(i) Metal sleeves around tubes, connected firmly to the chassis. 'Floating' metal shields used around subminiature tubes with resin castings are helpful, even when not connected to chassis, by distributing hot spots over a large area. For good thermal bond, welded or brazed joints are used instead of securing by means of fasteners.

(ii) Asbestos shields are used to keep heat away from critical points.[4]

(iii) Oil or Hydrogen is used in sealed equipments.[10]

(iv) Heat may be diverted by conducting it to a relatively large mass that is in proximity to the element.

(b) Heat radiation can be enhanced by

(i) Using materials with high emissivity and absorptivity. If the temperature of an object to be cooled is high, the area that the hot object 'sees' is made of a metal that will absorb the heat rather than reflect it back to the hot element.[4] Experiments[9] have proved that louvres provided in instrument cases did not make much difference, whereas, a finish with a high emissivity material dropped internal temperatures considerably.

(ii) Raising the temperature of the radiating body or lowering the temperature of the object that is to receive the radiation.

(c) Convection can be enhanced by

(i) Passing high velocity air over the surface to be cooled. In this case, there should be good 'scrubbing' in order to ensure that the object to be cooled is completely 'wiped'.[4] When forced convection cooling is used, outside air is collected and forced through ducts through the equipment or equipment bay where it takes up heat and it is expelled as hot air.[11]

(ii) Utilising a new approach for natural convection cooling by segregating the heat source from temperature sensitive components.[9]

LOW TEMPERATURE

The coldest regions encountered in India are in Jammu, Kashmir and the Himalayan border regions. The minimum temperature attained in these places is about–40°C.[2] Table I shows the minimum temperatures obtained at different places in India. In addition there is invariably a further chilling effect, Fig. (1)[4], due to cold winds blowing at high velocity–which is specified in terms of wind-chill-factor.[11] The effect of wind-chill on human beings is given by:–[11]

$$K = (\sqrt{100W} + 10.45 - W)(33 - T)$$

Where K = Total cooling, Kg cal/m^2/hr.
W = Wind velocity m/sec.
T = Temperature of the air, in °C.

In addition to the low temperatures mentioned above, a wind-chill-factor of 1,800–2,200 kgm calories per sq. meter per hour will also have to be taken into account.[2]

Under these conditions whilst the ambient temperature remains at–40°C, actual temperature of an exposed body may drop down to–80°C or even less.

Under such low temperatures the following difficulties are encountered.[3 4 11]

(a) Electrolytic capacitors become completely unsuitable.

(b) Quartz crystals frequently fail to oscillate.
(c) Storage battery electrolytes solidify.
(d) Dry batteries become unusable.
(e) Ordinary lubricants harden and the rotating
(d) shafts, gears and bearings of equipment may freeze. Waxes and protective compounds stiffen and crack. Rubber and rubber compounds in general lose their flexibility and become hard and brittle. Mechanically operated components such as switches, potentiometers, shafts, controls, gears and dials may fail on account of the grease freezing.
(f) Variations in the capacitance, inductance and resistance in component parts may be so great as to require readjustment of critical circuits.
(g) Plugs and sockets often cause trouble due to differential contraction of metal and plastic parts, causing poor contacts which are often difficult to trace.
(h) Relays often cause trouble due to contacts 'sticking' at low temperatures.
(j) Human endurance problems under low temperatures have also an indirect effect on the performance and maintenance of electronic equipment. Where no heating facilities are available, operation of knobs, switches and other controls, particularly in miniature equipments is a problem to manipulate with gloved hands. Mainteance is almost impossible without gloves. With gloves, it is difficult to handle small nuts, screws etc. and to remove and dismantle subunits. Moisture from breath of personnel condenses and freezes, causing further difficulties.
(k) Under very low temperatures the main danger is that snow may gain access to the interior of the equipment and may clog it or it may melt and refreeze inside as solid ice. Delicate mechanical parts may be damaged completely. It may bind moving parts and insulate contacts such as those found on relays and switches. The smaller the snow crystal and faster it is blowing, the more easily it can gain access to the interior. Equipment kept open for maintenance in the open is more liable to this hazard. Difficulties will also be experienced with equipment, taken from moist warm rooms to the cold outside because of condensation of moisture inside the equipment. An indirect hazard which may result to the equipment is that during transportation the snow clad terrain may impose very severe shocks and vibrations on the equipments.
(l) Low temperatures occur in India mostly on elevated regions. The reduction in atmospheric pressure gives rise to further problems.[3] Since the dielectric strength of air is proportional to its density, the insulating effect of air declines with increase in altitude and voltage flash-over between high tension points becomes probable. Components such as plugs in

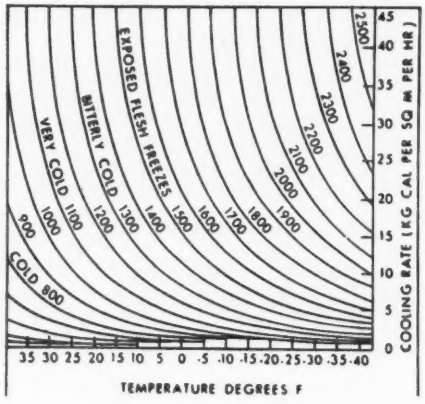


FIG. 1

electrical connectors fail because of the voltage breakdown between the pins and the shell across the surface of the insulating material. Vibrator and relay contacts are damaged more rapidly at reduced pressures since the intensity of the electric arc is increased upon making and breaking of the contact. Air dielectric condensers also become less reliable.

Although complete electrical breakdown does not take place over an insulating material, an electrical discharge consisting of minute arcs may occur at metal points or projections, where strong electric fields are built up so that the surrounding air is ionised. The electrical corona discharge losses occur under such circumstances. Ionisation of air produces ozone and oxides of nitrogen which are undesirable. Ozone readily oxidises natural rubber and some synthetics and the oxides of nitrogen combine with water to form acids which contaminate and degrade insulators and severely corrode metals.

Most of these difficulties caused by low temperatures could be solved if the equipment could be heated up. In operational conditions it is not however reasonable to expect such facilities.

PROTECTION AGAINST LOW TEMPERATURE HAZARDS

Therefore it is imperative to protect the equipment by suitable design remedies. A few methods presently adopted are:

(a) Design the internal layout in such a manner that the heat produced during operation is advantageously utilised to increase the ambient in the proximity of low temperature sensitive components.
(b) Avoid electrolytic capacitors, if possible.
(c) Avoid lead-acid and dry batteries. Instead use Nickel-Cadmium batteries which have better low temperature characteristics.[11 12]
(d) (Wherever possible) seal the equipment, preferably hermetically so that snow cannot gain access inside.

(Continued on page 18)

NEW PRODUCTS

NEW PORTABLE TENSILE TESTER COMBINES LABORATORY ACCURACY WITH PRODUCTION SPEED

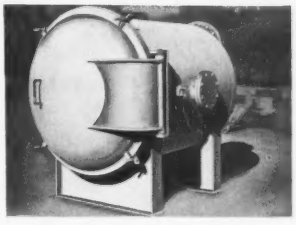
Tensile tests up to 500 lb can be accurately performed on a new portable instrument now available from Hunter Spring Company. Called the Series TJ Tensile Tester, the new air-actuated unit is designed for bench mounting and easy operation. Its speed makes it ideal for production testing, and its accuracy, one-half of one per cent of the full scale reading, makes it suitable for exacting laboratory tensile measurements.

Similar to the company's more specialized TT Series Tensile Testers, which have gained universal acceptance as the standard for testing solderless electrical connections in the electronics industry, the new TJ Series is designed to test a variety of small parts or material samples which can be held in its plier-like, in-line grip, such as wire, strip or bonded parts.

Heart of the new instrument is the Hunter Force Gage, a well known direct-reading gage for measuring tensile and compressive forces. The gage is mounted at one end of the tester base opposite the air motor. Extending from both the Force Gage and the air motor are two automatically operated jaws which hold the

In the standard Series TJ Tester the maximum jaw opening is ¼.; maximum travel of moving jaw is 2 in.; and minimum sample length is 1 in. However, these factors can be varied by modification of the instrument, or, in some cases by simple adjustments.

Seven models of the tester have maximum capacities of 20, 50, 75, 100, 150, 200 or 500 lb, respectively. The rugged, portable instrument has a durable and attractive black wrinkle finish. Its overall dimensions are 28¼ x 4½ x 8 in. and it weighs approximately 35 lb. Further information may be obtained from Quality Control Equipment Dept., Hunter Spring Company, A Division of American Machine & Metals, Inc., 1 Spring Avenue, Lansdale, Pa.



BETHLEHEM FOUNDRY ANNOUNCES SPACEMASTER VACUUM CHAMBERS

The Environmental Engineering Division of the Bethlehem Foundry and Machine Company, Bethlehem, Pa., has introduced the SPACEMASTER Series Vacuum Chambers. Bernard Friedman, manager of the division, announced that the series, a new concept of this type of equipment, offers vacuum equipment manufacturers and environmental engineers a complete line of vacuum chambers from 18 inches to 12 feet in diameter, with standard lengths up to 20 feet.

Mr. Friedman pointed out that these chambers are being made in two models: the standard unit for altitude simulation to 250,000 feet or approximately 10 microns, and the high vacuum series, which is provided with a stainless steel vessel for vacuum levels to 10-7 mm hg. This corresponds to altitudes in excess of 700,00 feet.

Bethlehem SPACEMASTER Chambers are delivered complete with mechanical or high vacuum diffusion pumping assemblies, or for use with customer supplied pumping systems. Popular models of the series are offered on a four to six week delivery schedule.

Inquiries in regard to the SPACEMASTER Chambers should be directed to Bernard Friedman, Manager, Environmental Engineering Division, Bethlehem Foundry and Machine Company, 225 W. Second Street, Bethlehem, Pa.

DRIVE MOTORS FOR NUCLEAR ENVIRONMENT

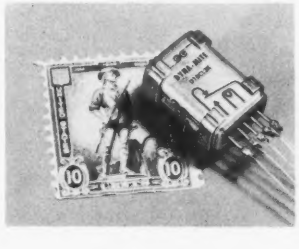
The Electro Products Division of Western Gear Corporation, 132 West Colorado Blvd., Pasadena, California, announces the design and manufacture of a Weir drive motor for use in nuclear radiation environment. Identified as Model 36V58RP143, it has an imput of 115 Volts, 3 phase, 400 cycle, with an output of 150 oz. in. at 12 rpm continuous duty. The temperature rise is 40° C. maximum. It measures 1.5 inches in diameter by 3.31 inches long not including shaft extension. It weighs 15 ounces. The manufacturer will supply further information on request.

The Electro Products Division of Western Gear Corporation, 132 West Colorado Blvd., Pasadena, California, announces the design and manufacture of a special motor made for use in nuclear radiation environment. Indentified as Model 32U21RP141, the motor which has integral gearhead has an input of 110 Volts, single phase, 60 cycle. Its output is 28 oz. in. torque at 20 rpm. The motor may be used in continuous duty service and has an operating life of 500 hours or an unattended life of one year. The ambient temperature is 100° C. The motor is designed and manufactured using lubricants and insulating materials which would not be damaged, produce outgassing or change mechanical and operating charact eristics by the following radiation dose:

2×10^9 Roentgens-Gamma Rays

5×10^{16}n vt-Fast Neutrons per Centimeter Squared

Its physical size is 3.31 in diameter by 5.5 inches in length, not including shaft extension. Its weight is 4 lbs. 11ozs. Further details may be obtained by writing the manufacturer.



CONTROL DYNAMICS UNVEILS NEW "DYNA-MITE" RELAY

NORTH HOLLYWOOD, Calif.—The first "reliable mite-sized relay to break through the shock and vibration barrier" has been announced by T. Ross Welch, President of Control Dynamics Corporation.

The tiny precision relay, called the Dyna-Mite, measures only .2 by .4 by .6 inches and has a volume of .048 cubic inches. It is sensitive (100 milliwatts), yet has only 1/16th the volume of a standard miniature relay. The weight of the hermetically sealed relay is .1 oz. maximum compared with an average of ½ oz. for standard Control Dynmics relays.

Rigorous tests have proved the performance of the Dyna-Mite under extreme conditions of vibration, shock and temperature, Welch said. Although rated at 20 g's to 2,000 cps, it has been repeatedly vibration tested to 45 g's without failure. In shock testing, it has withstood 100 g's with no failures, no "bounce" and no momentary contact openings.

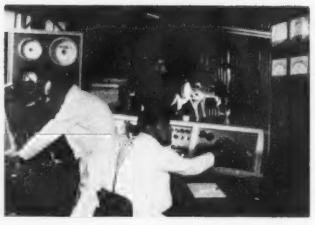
In other tests, Dyna-Mite relays have proved their ability to operate without variation over the entire ambient temperature range of -65° C. to +125° C. at the maximum guaranteed pull-in current of 7 MA. maximum for 2000 ohm coil; 18-30 volt rating.

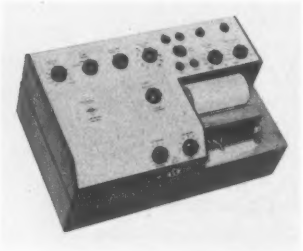
ONE MEGAWATT HYPERTHERMAL WIND TUNNEL BEING MARKETED BY PLASMADYNE CORP.

A new one-megawatt arc-heated hyperthermal test facility capable of accurately simulating critical reentry and ascent trajectories within the laboratory is now being marketed by Plasmadyne, Santa Ana, Calif., a subsidiary of Giannini Scientific Corp.

Technique used with the Plasmadyne facility is to simulate stagnation enthalpy and pitot pressure (stagnation pressure on nose or leading edge of vehicle) and not necessarily the free stream mach number or velocity.

According to Plasmadyne officials, standard heat transfer simulation range of the facility using a 3.0 inch diameter Mach number 3 test section, is between 10,000 and 30,000 ft./sec. simulated forceflight velocity. Simulated altitudes are as low as 100,000 ft. at 10,000 ft./sec. and as low as 200,000 ft. at 30,000 ft./sec. At higher altitudes and reduced power levels simulation of velocity to 35,000 t./sec. has been achieved.





TRUE RMS RECORDING VOLTMETER

The completely new Bruel & Kjaer Level Recorder Model 2305 is a high speed graphic recording voltmeter for measuring the True RMS, average, or peak level of AC signals from 10 c/s to 200 kc/s or signals DC to 10 c/s through an internal chopper. The recorder operates as a null balancing, electro-mechanical servo with six linear or logarithmic recording ranges of from 10 db to 75 db.

The Model 2305 contains the tuning drives and remote controls to integrate with other B & K instruments for automatic frequency response and calibration measurements or automatic frequency analysis.

Major applications are missile component testing for reliability in noise and vibration, commercial product noise and vibration control, and calibration of transducers and electronic devices.

Request Brochure BK 2305, B & K Instruments, Inc., 3044 West 106th St., Cleveland 11, Ohio.

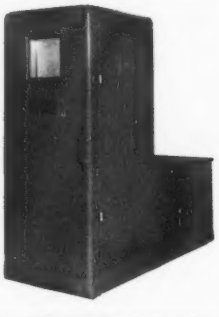
NEW WIRE TESTER EMPHASIZES ECONOMY OF SPACE

CINCINNATI SUB-ZERO PRODUCTS announces WU–100–24 for testing WIRE and CABLE under temperature conditions from plus 80 to minus 100°F ±2°F. The pulldown is accomplished in sixty minutes.

The specially designed chamber, measuring 24" Wide, 26" Deep, and 72" High, is penetrated by a self-supporting cone-step mandrell which provides for testing on 2", 3", 4½" and 6" diameters. It may be used on the side, or the back wall of the chamber, and the rugged pillow-block construction will accommodate a test load of ½ ton.

Two 2" ports, 12" x 12", frost-free multipane window, and interior illumination, complete the appointements. The chamber incorporates a specially ducted fin coil evaporator on the rear wall which allows unencumbered use of the entire test area.

The power pack operates on current requirements of 230 volt, 60 cycle, 1 phase, and the overall dimensions are 34" Wide x 36" Deep x 86" High.



(Continued from page 16)

(e) Design the controls in such a way that they could be conveniently handled by gloved hands. In miniature equipments, the use of a tied key and slot, can overcome the problem of closely spaced knobs."

(f) Use correct lubricants. (if not available, do not use lubricants at all.)"

(g) Seal and pressurize the equipment so that all components operate virtually as at sea-level.

(h) Use normal open construction spacing for all high voltage points.

(Continued next issue)

Editor's Note

The unfortunate set of circumstances occuring in the February Issue of "The Journal" have brought to our attention the fact that many authors are submitting their manuscripts to more than one publication. We would like to point out that we do not assume responsibility for unsolicited manuscripts and also that authors do have a degree of responsibility for their manuscripts. If you do submit your articles to more than one publication, please inform all concerned when arrangements have been made for publication.

Apology

We, the Editors & Staff, wish to express our apologies to Mr. S. P. Sanders of Bendix Corporation for any embarassment caused him by the publishing of his article "Environmental Imagineering" in the February issue. Our apologies also to the other publication which has scheduled this article for their April issue.

Membership in IES

Several classes of membership are provided in the Institute of Environmental Sciences which parallel those of other societies, namely: Fellow, Honorary Fellow, Member, Associate Member, Student, Government Member, and Company Member. Requirements for the individual classes of membership have been established and will be available upon application for membership. All past members of SEE and IEE have automatically been assigned the member classification without further qualification. Fellows and Members are eligible to vote and hold office. Associate Members may vote but cannot hold office. Student, Government and Honorary Members do not vote or hold office.

APPLICATIONS

For further information regarding membership write to The Institute of Environmental Sciences, Box 191, Mt. Prospect, Illinois. Attention: Leon Carver, Vice President, Membership.

(Continued from page 8)

ing wire on the capsule carries the necessary information. The trailing wire is obviously impractical for a spinning capsule. The problem was solved with a small telemetry system in the capsule, which transmitted information from an angular accelerometer to a receiver in the plane (Figure 6). With this setup, accurate measurements of wobble buildup could be made.

To conduct a test, the capsule was spun up on the turntable. At a signal from the pilot a magnetic holddown was released, allowing the capsule to float away. The turntable was then pulled away so it did not interfere with the floating capsule. Figure 7 shows a test in progress. The personnel are preparing to catch the capsule after it hits the wall of the airplane.

Using this procedure, 14 flights were conducted, and a total of about 250 maneuvers were made over a period of three weeks last August.

Our results showed that, while the wobble amplitude increased as expected, the rate of growth was slow enough to be safe, so that the Able-5 mission was possible.

CONCLUSION

The airplane test technique is a very useful and very general one. The WADD people are extremely cooperative and very much interested in research on effects of zero-gravity. For Organizations interested in using the WADD zero-gravity facility, the names of contact people at WADD will be provided on request.

I.E.S. NEWS LETTER

NEW YORK CHAPTER:

The Third Annual Symposium of the New York Metropolitan Chapter was held on Dec. 8, 1960 at the Hotel Henry Hudson, New York. This years theme was "Man's Environment in Outer Space".

DETROIT CHAPTER:

The Detroit Chapter had its latest meeting in January and a record attendence was logged. Members came by bus from as far as Grand Rapids and others flew in from Holland, Mich.

Guest speaker was A. Scott Crossfield

GREATER CHICAGO AREA CHAPTERS:

A meeting was held on Feb. 8, 1961. It was a combined meeting with The Chicago Chapters of the IES, ARS, CAAG-IRE.

Guest speaker was Mr James A. Hill, North American Aviation, who spoke on "Acoustic Testing & The Flight Vehicle".

SAN DIEGO CHAPTER:

The San Diego meeting was held on Feb. 8, 1960. Mr. William K. Stuart, Project Engineer, Dynapak/Convair, spoke on "From High-G to Hyge".

LOS ANGELES CHAPTER:

David A. Lee, Member, Technical Staff, Space Technology Labs, was guest speaker at the February meeting of the L.A. Chapter. His Topic was "Test in a Zero-G Environment". Movies were shown of men and equipment being subjected to zero-g environments.

NATIONAL OFFICERS

Election of national officers are here again and we, the Editors, wish to thank each of the retiring officers for their help and cooperation in the past year.

WILLIAM VANDAL
President

ARTHUR BILLET
Exec. Vice President

RAYMOND YAEGER
Vice President, Fiscal Affairs

LEON CARVER
Vice President, Membership

HENRY SANDER
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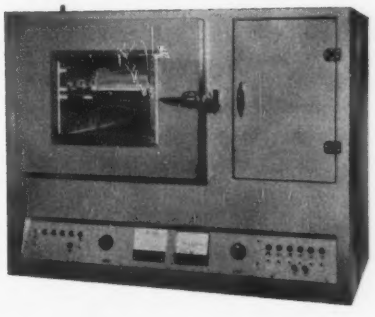
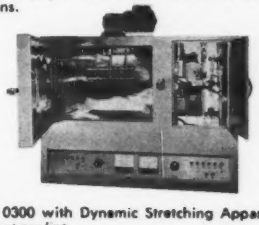
TLARGI, U.S.C.
U. S. Rubber Company
Shell Chemical Corporation



Orec 0300 Series employ an *electronic-chemical loop feed back servo system to achieve and precisely maintain chamber ozone concentrations.



Orec 0300 with Dynamic Stretching Apparatus.
* *patent pending*

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TECHNICAL INFORMATION

ACCELEROMETER FREQUENCY CALIBRATION

B & (Instruments, Inc. of 3044 West 106th Street, Cleveland, Ohio, announces the publication of a 28–page Bruel & Kjaer Technical Review describing the electrical and mechanical performance characteristics of the high frequency Calibration Exciter Model 4290. The problems and techniques of calibrating accelerometer frequency response from 20 c/s to 30 kc/s are discussed. A copy may be obtained by requesting Technical Review "Vibration Exciter Characteristics".

UNITED TESTING LABORATORIES ESTABLISHES NEW FACILITY.

United Testing Laboratories, a Division of United Electro-Dynamics, Inc., has established a new branch environmental testing laboratory located at 150 Wolfe Road, Sunnyvale, California.

Mr. F. K. van Biene, United ElectroDynamics, Inc. Vice President and Manager of United Testing Laboratories, stated that the San Francisco Bay branch will be capable of providing environmental testing services for all types of electronic parts, components, and systems. The technical staff, supported by a complete line of test equipment, will be capable of conducting R&D, Qualification, Reliability, and Quality Control testing projects.

In addition, the testing staff will be supported by a group of reliability engineering specialists. These specialized technical skills are being provided in order to assist the customer in test program planning and preparation of complex test procedures.

Mr. C. D. Richmond, formerly test supervisor of the electronic testing department at United Testing Laboratories' main plant in Monterey Park, California has been appointed Branch Manager.

GENERAL ACOUSTICS EXPANDS SALES ACTIVITIES

General Acoustics Corporation, designers and manufacturers of prefabricated modular structures used in aircraft, missile and electronics industries, have appointed two firms as engineering sales representatives in the Southern California area, states Cloyd Smith, President.

C. C. Moore and Company, located at 405–A Via Corta in Palos Verdes Estates, will handle sales of GAC prefabricated Dust Free Rooms.

Smith-Dietrich Sales Company, whose offices are at 405 W. Manchester Boulevard, Suite 3, in Inglewood, will concentrate on sales of GAC prefabricated RF Shielded Rooms.

Each of these firms will assist GAC in a first step expansion program for national sales and engineering activities on the new prefab modular space age structures.

NEW! 60–PAGE CATALOG FEATURES "SIMPLE-TO-ORDER" FORMAT

A new 60-page catalog containing complete specifications, details and prices on thermocouples, pressure probes and allied components has just been announced by Advanced Dynamics Inc., 16321 Rockside Road, Cleveland 37, Ohio.

According to the manufacturer, the new catalog offers an "off-the-shelf" line of industrial thermocouples and pressure probes, manufactured with aircraft qualit and sold at competitive industrial prices. The manu facturer also states that a unique "simple-to-order' format makes the catalog an easy buying reference.

Copies of the catalog may be had by writing direct to Advanced Dynamics Inc., 16321 Rockside Road, Cleveland 37, Ohio.

COMPUDYNE CORPORATION ENTERS TELEMETERING FIELD

CompuDyne Corporation of Hatboro, Penna. has entered the telemetering field. Telemetering is the method of transmitting information to a distant receiver by means of an electronic device that measures pressure, temperature, flow, level, etc. In addition to specific equipment being introduced, a full-scale development program will cover all phases of telemetering.

In making the announcement, Charles D. Close, CompuDyne's President, commented "Properly applied telemetering can supply a vital link in completely automatic process control. CompuDyne's entry into the field marks a significant forward step for the Company and the systems we offer. Some of the developments already underway promise wide application in process industry's research and defense systems."

J. T. SLOCOMB CO. OFFERS NEW CATALOG

South Glastonbury, Conn.–J. T. Slocomb Co.'s popular direct reading micrometer, the Speedmike and the unique Snap Gage Micrometer are described in detailed fashion in a new catalog sheet recently issued by the manufacturer.

Offered free, the literature includes information on the advantages of direct reading micrometers over conventional types and explains how the Snap Gage Micrometer may be used to eliminate an entire set of fixed snap gages. Information on optional features and optional features and optional terminals available is also included.

Write: J. T. Slocomb Co., 68 Matson Hill Road, South Glastonbury, Conn. for Bulletin No. 11.

TENNEY ENGINEERING, INC., REALIGNS AEROSPACE, ENVIRONMENTAL DIVISIONS–GARDNER, SCHLETTER NAMED MANAGERS

Tenney Engineering, Inc., Union, N. J., has organized independent divisions for its aerospace and environmental equipment, with Frank H. Gardner and Martin Schletter as managers of the respective operations. Both Mr. Gardner and Mr. Schletter are veteran development engineers at Tenney, world's oldest and largest manufacturer of simulation devices.

Monroe Seligman, president of Tenney, said the aerospace and environmental assignments complete a functional realignment that has resulted in the creation of five separate divisions within the company. An Acoustics Division and a Ground Support and Systems Engineering Division were announced recently. The fifth division is Tenney's Heating, Refrigeration and Air Conditioning Products Division, whose plant is in Wilmington, N. C.

"The divisional organization reflects the growth of the company and the sophisticated nature of its markets," Mr. Seligman said. Simulators such as will be handled by the Environmental Division were considered very advanced only a year ago, and are still very much in demand. But the race into space has created a new, parallel demand for orbital simulation, which involves new engineering concepts, multi-million-dollar contracts and different sales approaches."

Environmental and orbital simulators are used to create extreme altitude, temperature and solar conditions for pretesting industrial products and space, missile and jet components and structures.

Mr. Gardner has been with Tenney for 10 years. A graduate of the City College of New York, he also has studied at Ohio State University and the Shrivenham Division of Oxford University in England. He is a member of the American Society of Mechanical Engineers, American Society of Refrigerating Engineers, American Vacuum Society and the Institute of Environmental Sciences. He lives at 865 Floral Ave., Union, N. J.

Mr. Schletter, of 110 Roosevelt Ave., West Orange, N. J., joined Tenney nine years ago. A graduate of George Washington University, he is a national director of the Institute of Environmental Sciences and past chairman of its Mid-Atlantic chapter. He is also a member of the American Ordnance Association, the Armed Forces Communications and Electronics Association and the Instrument Society of America.

names and faces

A. L. LISLE NAMED GENERAL MANAGER OF CONTROL DYNAMICS CORPORATION

NORTH HOLLYWOOD, Calif.—*A. L. Lisle* has been appointed Executive Vice-President and General Manager of Control Dynamics Corporation, according to an announcement by *T. Ross Welch*, President of the relay manufacturing firm.

In his new capacity, *Lisle* will assume responsibility for "total company operations," with the exception of engineering and product research and development. These will continue to be under the personal direction of *Welch*, company founder and nationally recognized authority in the fields of micro-miniature and "mite-sized" relays.

Before joining Control Dynamics, *Lisle* was with Kearfott Division of General Precision, Inc., for five years. His experience here includes two years as sales manager of Microwave Products and three years as production manager of the same firm. A native of Los Angeles, *Lisle* is a graduate of the University of Southern California.

WILLIAM G. DUNN NAMED MANAGER, ACOUSTICS DIVISION TENNEY ENGINEERING, INC., UNION, N.J.

Tenney Engineering, Inc., of Union, N. J., a major manufacturer of environmental and orbital simulators and electronic and ground support test equipment, has organized a new division to produce sound sources and special enclosures for acoustical testing, Monroe Seligman, president of Tenney announced.

William G. Dunn, formerly lead engineer of the acoustic test section of North American Aviation, Inc.'s Dynamics Laboratory, Columbus, Ohio, has joined Tenney as manager of the new division.

Mr. Seligman said the division's first assignment was the development of sound source machines capable of intensities never before achieved. Such equipment is vitally needed for testing jet aircraft and rocket components and structures, as well as in industrial applications.

STRONG ELECTRIC CORPORATION APPOINTS NEW REPRESENTATIVE

Don E. Huges, Los Angeles, has been appointed California and Arizona representative of The Strong Corporation, Toledo, developers of and manufacturers of the Strong blown type Jetarc solar radiation simulator.

Mr. Hughes, who received his engineering degrees from Purdue and Stanford, has been associated with the field of environmental test equipment for ten years. He was formerly associated with Standard Oil of California, Owens-Corning Glass Co., and the Throson Co. of Los Angeles.

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NOTES FROM THE EDITOR

The 1961 annual meeting of the Institute of Environmental Sciences will soon be in progress during April 5, 6 and 7. Papers presented during the meeting will cover many different areas related to the Environmental Sciences. The Program Committee has done an excellent job in arranging for the three day technical series in order that authors of papers can personally present the latest information in the Environmental fields. The members of the local chapter should be commended for their work in providing the facilities and arrangements as hosts of this national meeting.

Of immense value to the environmental industry will be the publication of the 1961 Proceedings containing all papers presented at the technical sessions. The distribution of these Proceedings compliments the technical articles published in the Journal on a bimonthly basis.

The purpose of the Society and the Journal is not only to extend the knowledge of the environments, but also to advance the latest techniques and methods of providing qualification of a company's product and insure reliability of that product in the field.

A wide range of topics which can be used as a guide for submitting articles to the Journal are outlined in the February 1961 issue of the Journal and the article format was briefly discussed in the February 1960 issue.

It is extremely important that members of the Institute of Environmental Sciences support their Society and its Publication by submitting their articles for publication in the Journal. Only in this manner can they be assured of circulation of technical information to all Society members.

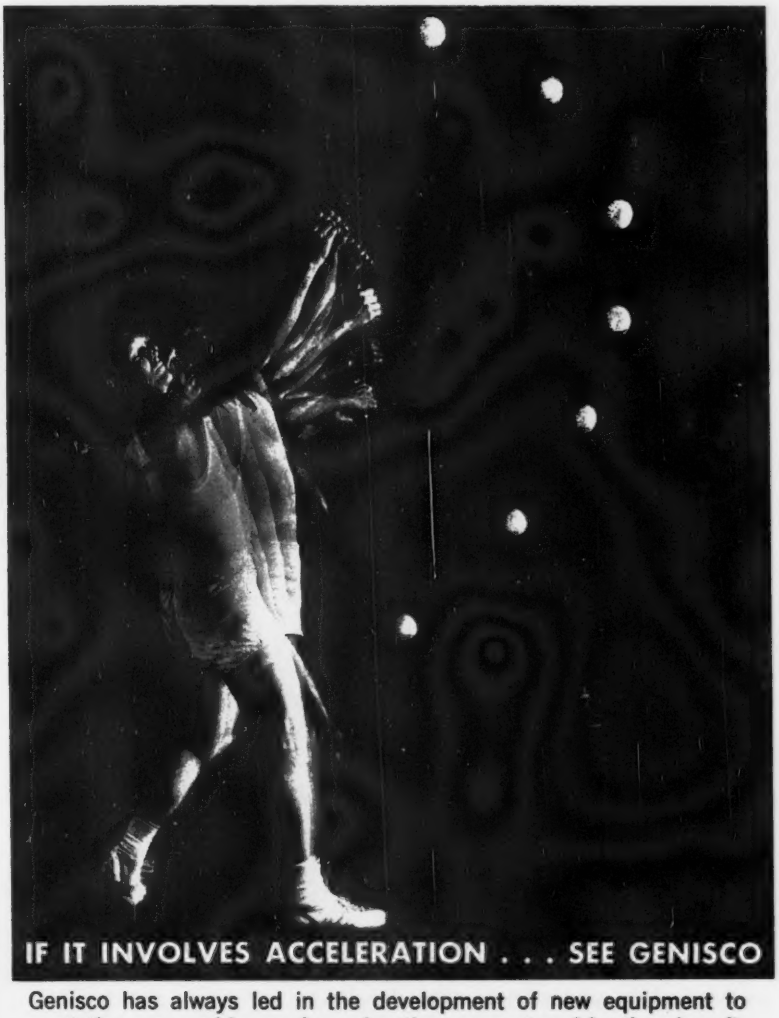
This national meeting also means a change of personnel on the Journal. After two years as Technical Editor, it is my pleasant duty to turn over the reins to Mr. Robert Whiting who has done an excellent job as Assistant Technical Editor during the past year.

Mr. Whiting is looking forward to serving two years as the Technical Editor, while I shall continue to contribute to the Journal growth in the capacity of Contributing Editor.

I wish to thank all of you that have given your time and efforts to the Journal, and hope that during the next two years all members will contribute to and support their new Technical Editor, Mr. Whiting.

CHARLES W. DANIELSON

ROBERT WHITING



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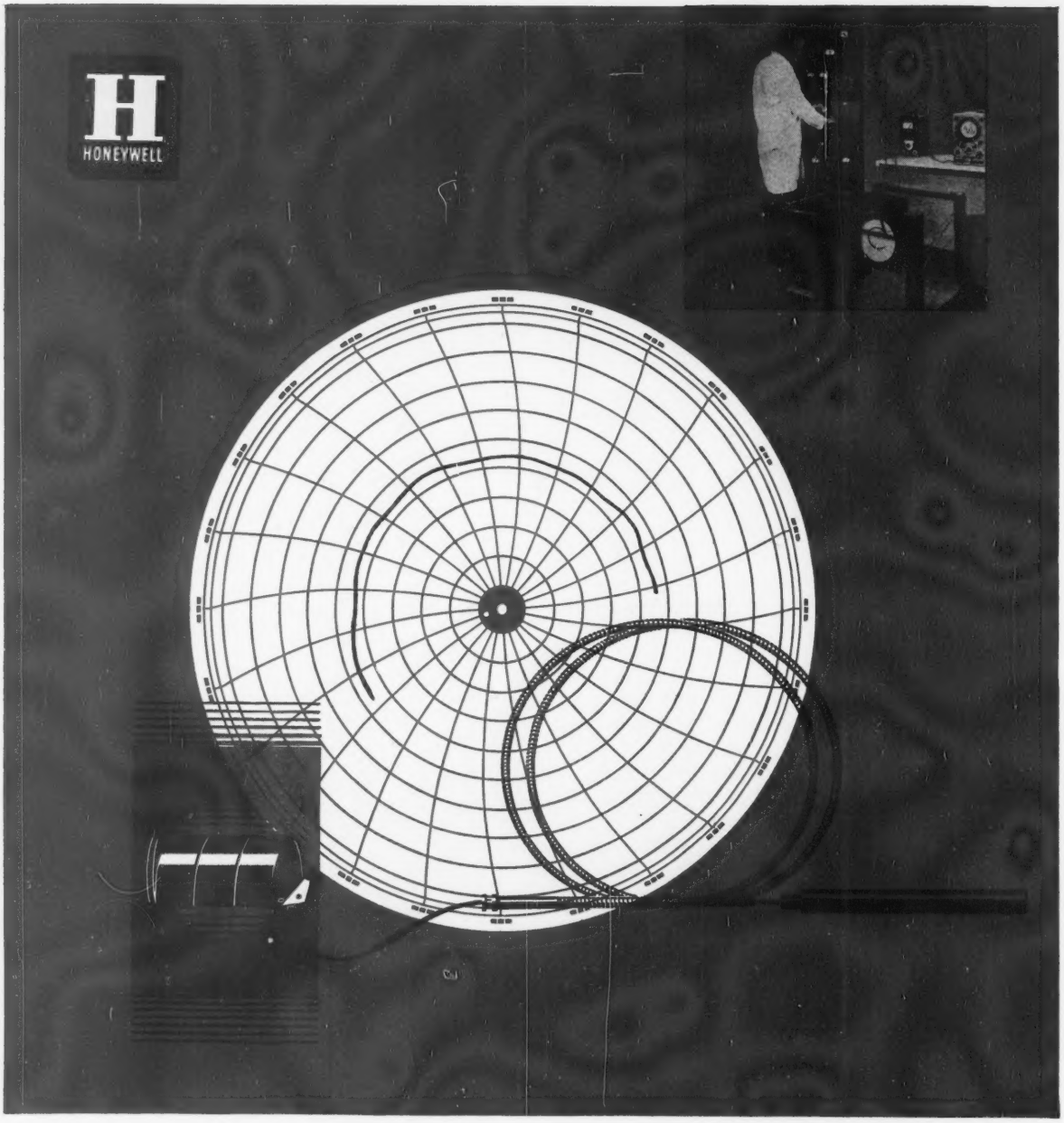

The New Honeywell Thermal System withstands extreme vibration and corrosion conditions

Here's a new gas-actuated thermal system that takes the zig-and-zag out of temperature recording under severe vibration conditions.

A complete series of vibration tests has proved the vibration resistance of the new Class III thermal system. In these tests (shown above), the Class III system was installed in a standard Honeywell rectangular case recorder, and subjected to forced vibrations in three mutually perpendicular planes. With accelerations up to 0.2G from 0 to 200 cps, maximum pen oscillation was limited to 1.5%. For more than 75% of the range, pen oscillation was less than 0.5%, with no resonant effects at 60 cycles.

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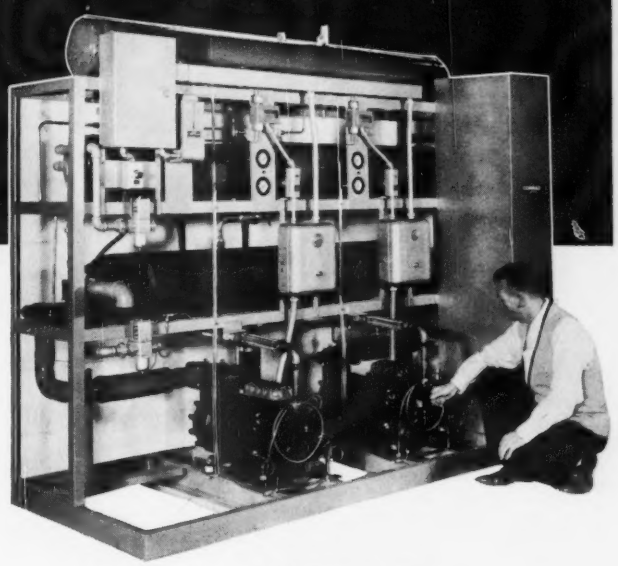

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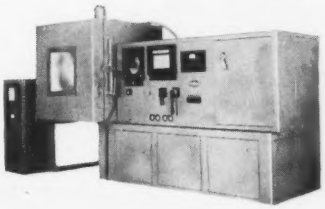
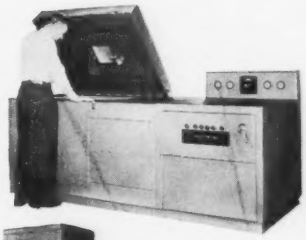
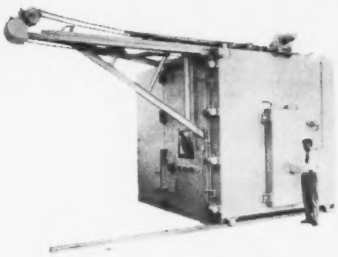
Typical Conrad Environmental Test Chambers



Cat. No. 60502 — Temperature - vibration - altitude, with radiant heating.



Cat. No. 58707 — Standard 8 cu. ft. chest, −100° F. to +300° F.



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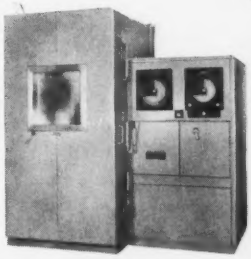
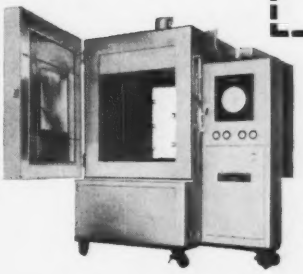
Cat. No. 61201 — Multiple temperature baths, +30° F., 0° F., −20° F., −60° F., −90° F.



Cat. No. 58732-S — Temperature-humidity chamber, especially designed for electronic system relay racks.



Cat. No. 61202—30 cu. ft. temperature test unit, with pass-through doors.

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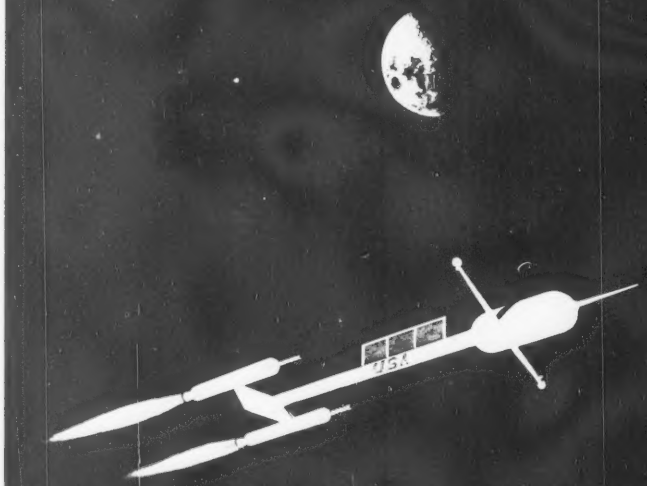
THE RACE INTO SPACE



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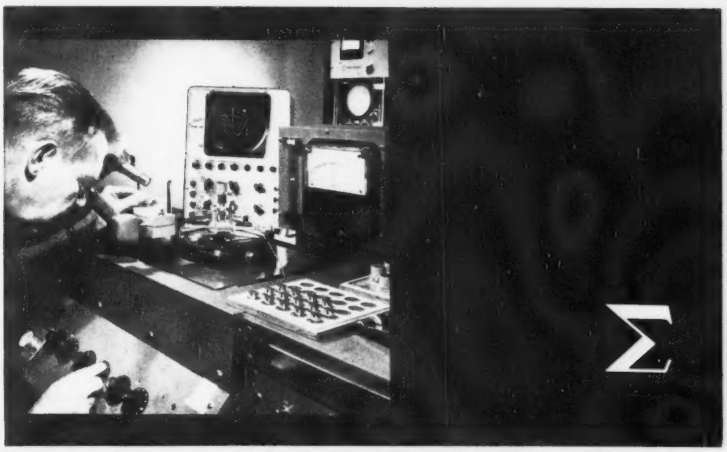

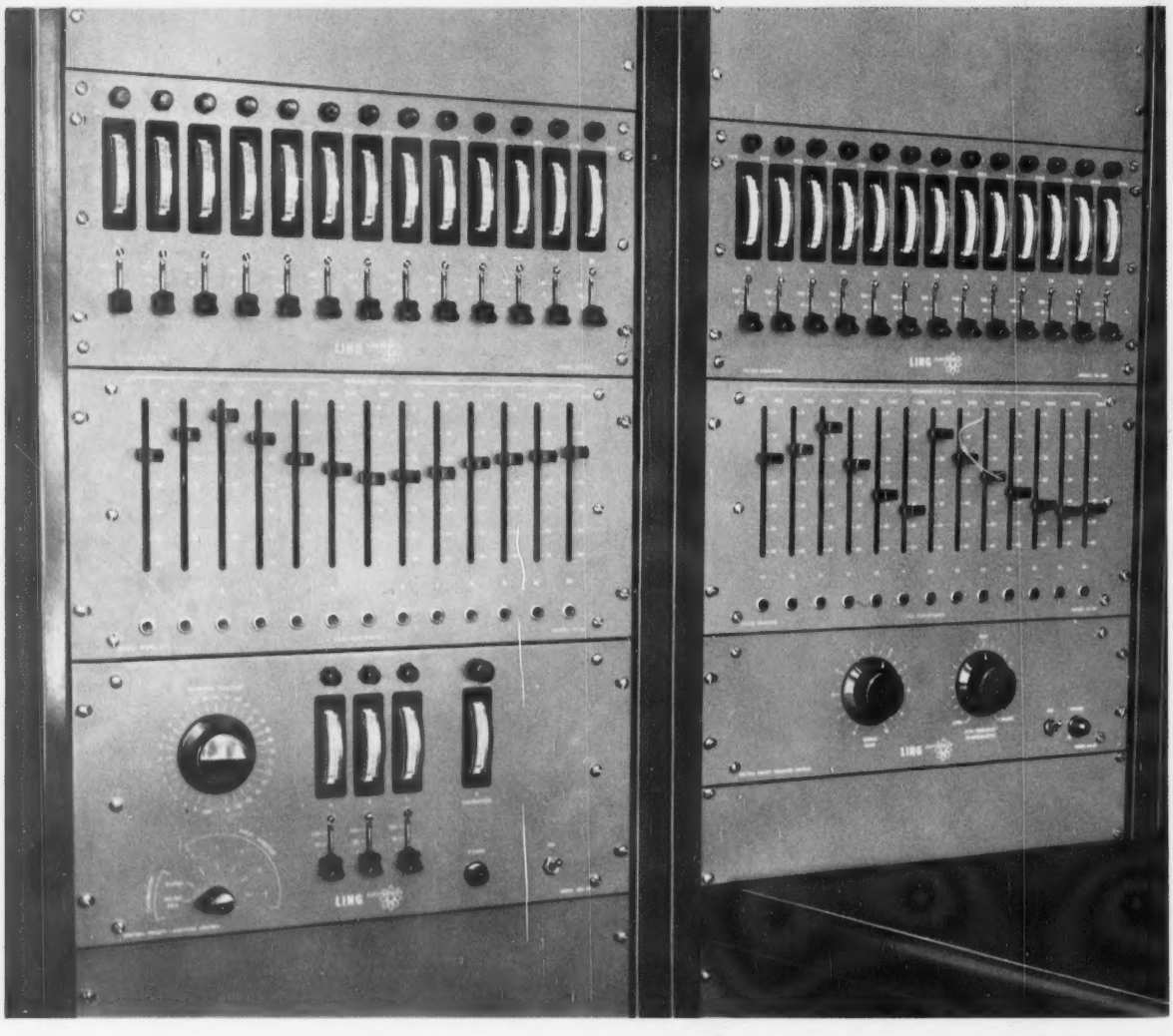

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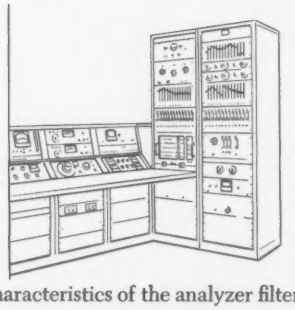

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